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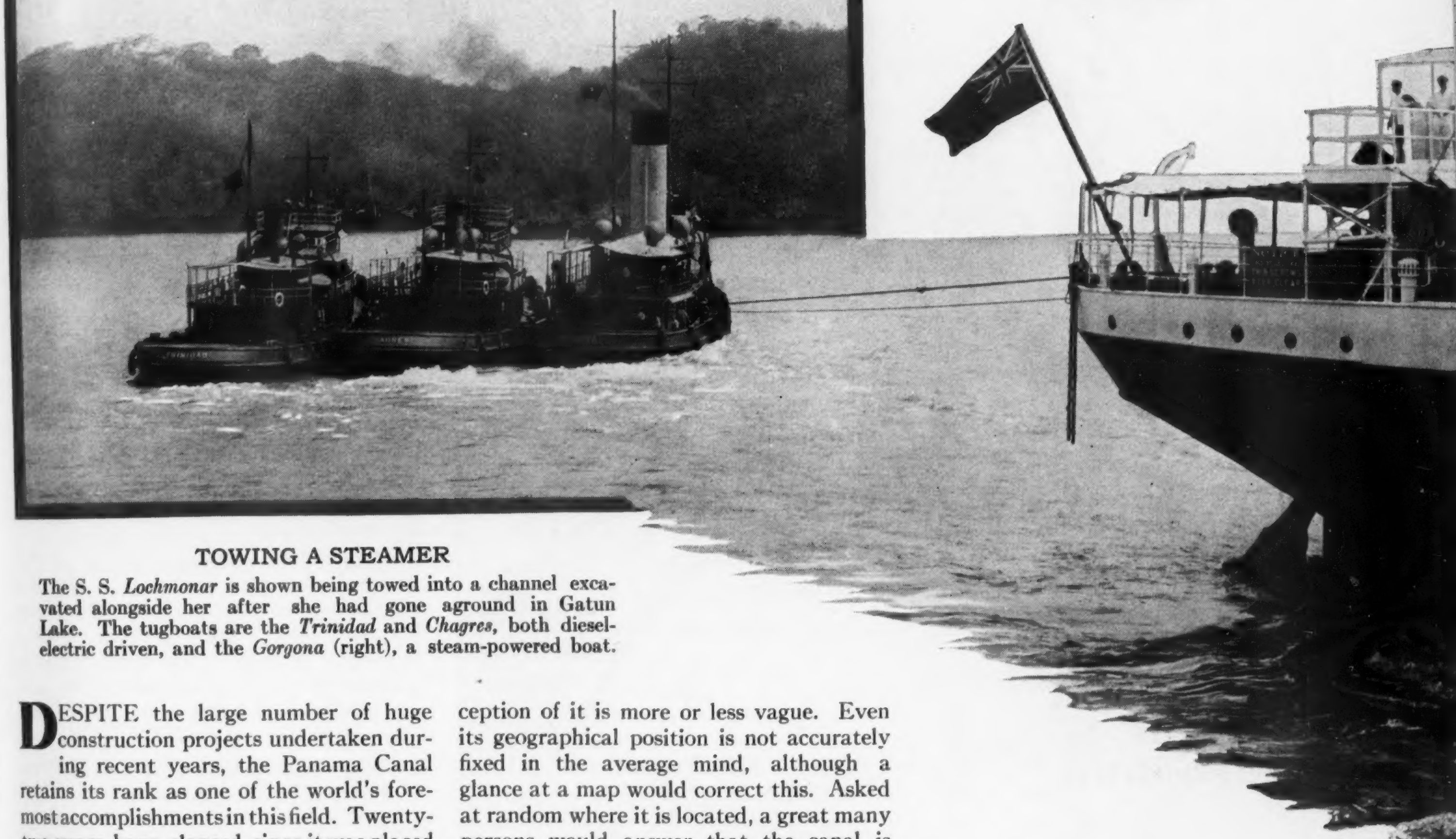
THIS illustration depicts the pouring of a casting in a gray-iron foundry, an operation that is typical of the hundreds of plants in the United States that manufacture heavy machinery. It is reproduced from an oil painting by C. F. Schwep, a vice-president of Ingersoll-Rand Company, New York City. Mr. Schwep became interested in the painting of industrial scenes several years ago, and has since made it his principal diversion. Copies of the reproduction, suitable for framing, may be obtained by writing this Magazine.

The Panama Canal

C. H. Vivian



TOWING A STEAMER

The S. S. *Lochmonar* is shown being towed into a channel excavated alongside her after she had gone aground in Gatun Lake. The tugboats are the *Trinidad* and *Chagres*, both diesel-electric driven, and the *Gorgona* (right), a steam-powered boat.

DESPITE the large number of huge construction projects undertaken during recent years, the Panama Canal retains its rank as one of the world's foremost accomplishments in this field. Twenty-two years have elapsed since it was placed in service, and still the "Big Ditch" continues to hold its glamour. The story of its building will remain for a long time one of the brightest chapters in the annals of American engineering achievement. Following, as it did, the ill-starred venture of the French under the great Ferdinand de Lesseps, of Suez Canal fame, the success of Uncle Sam's engineers in the face of extremely severe conditions won the plaudits of the world.

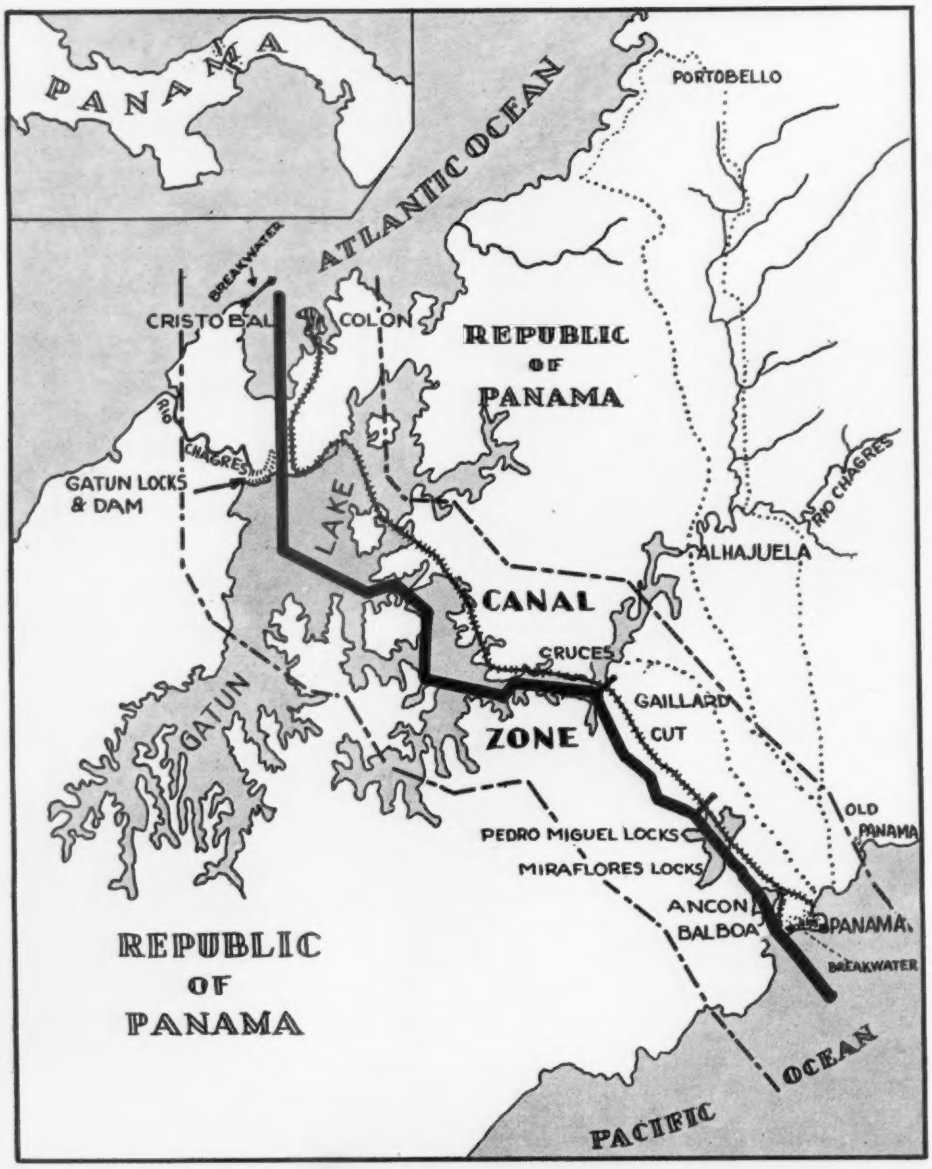
As is well known, the building of the canal was not only an engineering epic but a victory over pestilence and a sultry, tropical climate. Conducted, as it was, far from the seat of government, it took on the aspect of a conquest. Only figures can convey an idea of its stupendousness. The 242,000,000 cubic yards of material moved during its construction would form a row of pyramids—each the size of the famous Pyramid of Cheops—eleven miles long and with base touching base. In every way, the Panama Canal still lives up to the characterization given it by Lord Bryce, namely, that it is "the result of the greatest liberty man ever took with Nature."

Unfortunately, the canal is beyond the travel range of the average American. Consequently, knowledge of it comes secondhand at best to most of us, and our conception of it is more or less vague. Even its geographical position is not accurately fixed in the average mind, although a glance at a map would correct this. Asked at random where it is located, a great many persons would answer that the canal is roughly south of California. This is a natural mistake, as we think of the *cordillera* that connects North America and South America as extending on southward after it passes the boundary between the United States and Mexico. The fact is that the canal is almost due south of Pittsburgh. Contrary to the usual belief, it is much nearer New York City than San Francisco, the sailing time being five or six days from New York and ten or eleven days from San Francisco, depending upon the number of calls *en route*. A second surprise comes to many of us when we learn that the Atlantic end is farther west than the Pacific end. As an inspection of the accompanying map will show, the canal runs in a general northwest-southeast direction.

The digging of the Panama Canal was inevitable. Columbus's motive was, of course, the finding of a passage from Europe to India, and he explored the coast of the Spanish Main firmly convinced that there was an opening there somewhere. Succeeding voyagers from the Old World were equally confident that such a waterway existed, and it was with great reluctance that they finally accepted the idea that there was no break in the land. With this fact established, the cutting of a channel was almost immediately proposed.

As early as 1550 the Portuguese navigator Antonio Galvao published a book advocating the building of a canal, and this was followed by direct requests to the Spanish Crown that the work be undertaken at once. But the Spanish Government did not care to make it too easy for other nations to reach its New World possessions. Much treasure was coming out of Peru and being borne overland to the Atlantic Coast on a highway that stretched from Porto Bello to the old city of Panama. Not only was a canal opposed but even the seeking of another land route was forbidden under penalty of death. Thus, for two centuries the movement was held in check, but in 1771 the Spanish Government reversed its stand and ordered surveys made for a canal.

Political upheavals in Europe prevented further consideration of the project at the time; but in succeeding years various nations gave the matter thought, and a number of concessions were granted from time to time. In the United States, the great increase in travel occasioned by the California gold discovery in 1848 gave the movement added impetus, for it was easier and less hazardous to sail to the Isthmus and to transport goods across it and reload them



MAP OF THE CANAL

Gatun Lake, the surface of which is 85 feet above sea level, was formed by damming the Chagres River at Gatun. The dam is 8,400 feet long at the crest, which is 105 feet above sea level. The new Madden Dam is located on the Chagres River near the Village of Alhajuela. The dotted lines on the right-hand side indicate the old paved highways which were the only means of crossing the Isthmus for several centuries.

in ships bound up the Pacific Coast than it was to make the long overland trip across the continent. The rush to California actually pushed to completion the building of a transisthmian railroad, as will be mentioned later, but it did not suffice to bring about the digging of a canal. With the construction of the Union Pacific Railroad across the western part of the United States was removed for the time being the need of such a waterway so far as this country was concerned.

However, the determination that a canal should be built grew greater rather than less and led to the valiant but unsuccessful attempt of the French. Meanwhile, American agitation for a canal had been growing, and it amounted almost to a demand when the historic run of the *Oregon* during the Spanish-American War demonstrated the great need of a shorter passage between the east and west coasts. But more consideration had been given to a Nicaragua route than to one through Panama, and it was only through the herculean efforts of the Panama proponents in a hectic session of Congress that the bill was passed which left the choice of routes to President Theodore Roosevelt. There remained to be consummated a treaty with Colombia, to which Panama was then subject, and payment to the French interests of $40,000,000 for all their rights, concessions, and construction equipment. The American Congress debated the treaty for three months before ratifying it, and then the Colombian Congress sought to hold it up. The matter was settled, but not without bitterness, when Panama declared its independence—a move to which the United States lent tacit approval when it immediately recognized the new government and concluded a treaty with it. However, time has proved the wisdom of that action, for all the nations in the region of the canal, including Colombia and Nicaragua, have benefited by it, with the result that all old sores have been healed. This is the skeletonized story of the end of the search for a new route to the East that Columbus began four centuries ago.

For the casual visitor to the canal, there are two distinct interests—the physical and the romantic. Physically, of course, the canal is prodigious. Its over-all length from deep water to deep water is approximately 50 miles. Of this, about 4½ miles in Limon Bay at the Atlantic end and 5 miles on the Pacific end are dredged in the ocean. Of the inland section, approximately 23½ miles traverse Gatun Lake, which was formed by damming the Chagres River. A further stretch of a mile or more is formed by Miraflores Lake, so that only about 16 miles of the waterway has the appearance of a canal. Most spectacular, of course, is the Gaillard Cut (formerly the Culebra and renamed for Maj. D. D. Gaillard, who was in charge of the excavating and dredging operations during the construction period).

At that point the canal follows an 8¾-mile gash through a mountain, a gash that tried the hearts of men in its making. From it was removed between 1904 and 1914 an aggregate of 103,000,000 cubic yards of material of which 22,000,000 cubic yards was precipitated into the gorge by slides. Since 1914 there has been removed from the cut more than half as much material as was originally excavated, and of this some 85 per cent was contributed by slides.

The visitor naturally can gain no true comprehension of the canal excavation, for much of it is underwater. The depth varies from 42 to 45 feet. The bottom width is at least 500 feet, except in Gaillard Cut where it is 300 feet; and in certain enlarged waiting basins it is as much as 1,000 feet. To reach Gatun Lake and Gaillard Cut, where the surface of the water is 85 feet above mean sea level, ships are raised and lowered by a series of locks. Entering the canal from the Atlantic side, they are elevated at Gatun in three consecutive lifts of 28⅓ feet each. The descent on the Pacific side is made in three steps at two locations. At the end of Gaillard Cut a drop of 30 feet is made to Miraflores Lake by way of the Pedro Miguel locks. After traversing that lake, the vessels are let down to sea level in the Miraflores locks.

All the locks are built in duplicate, and each has a usable area 110 feet wide and 1,000 feet long. Originally they were to have a width of 96 feet and a length of 900 feet. The announcement of the plans to build the *Olympic* and *Titanic* caused President Theodore Roosevelt to order the locks enlarged, Congress having vested him with authority to provide a canal big enough to accommodate the largest ships then afloat or projected. For the same reasons he ordered a minimum bottom width

for Gaillard Cut of 300 feet instead of 200, as was originally provided for.

The Canal Zone, a corridor 10 miles wide, was acquired by the United States from the Republic of Panama in 1904, thus placing the canal on American soil. The chief administrative officer is the governor, who is always a U. S. Engineer officer. He serves as engineer of maintenance of the canal and then succeeds to the governorship. The zone has an area of 553.8 square miles and a population of about 40,000.

Although they are in the Canal Zone, the cities of Colon, on the Atlantic side, and Panama, on the Pacific side, remain under the control of the Republic of Panama save in all matters relating to sanitation and quarantine. Part of Colon occupies made land which was placed by dredging. The site belongs to the Panama Railroad & Steamship Company, which is owned by the United States Government. Both these native cities are of great interest to tourists, particularly because their shops abound with linens, silks, ivory, and other imported articles, which are attractively priced by virtue of the fact that they are duty free. As it normally requires seven to eight hours for a ship to pass through the canal, most passengers leave the boats at the entrance and cross the Isthmus by train, thereby gaining five or six hours which can be spent in shopping and sightseeing. At the Atlantic end the traveler will find a modern hotel, the Washington; and there is also the Strangers Club, a rendezvous for tourists.

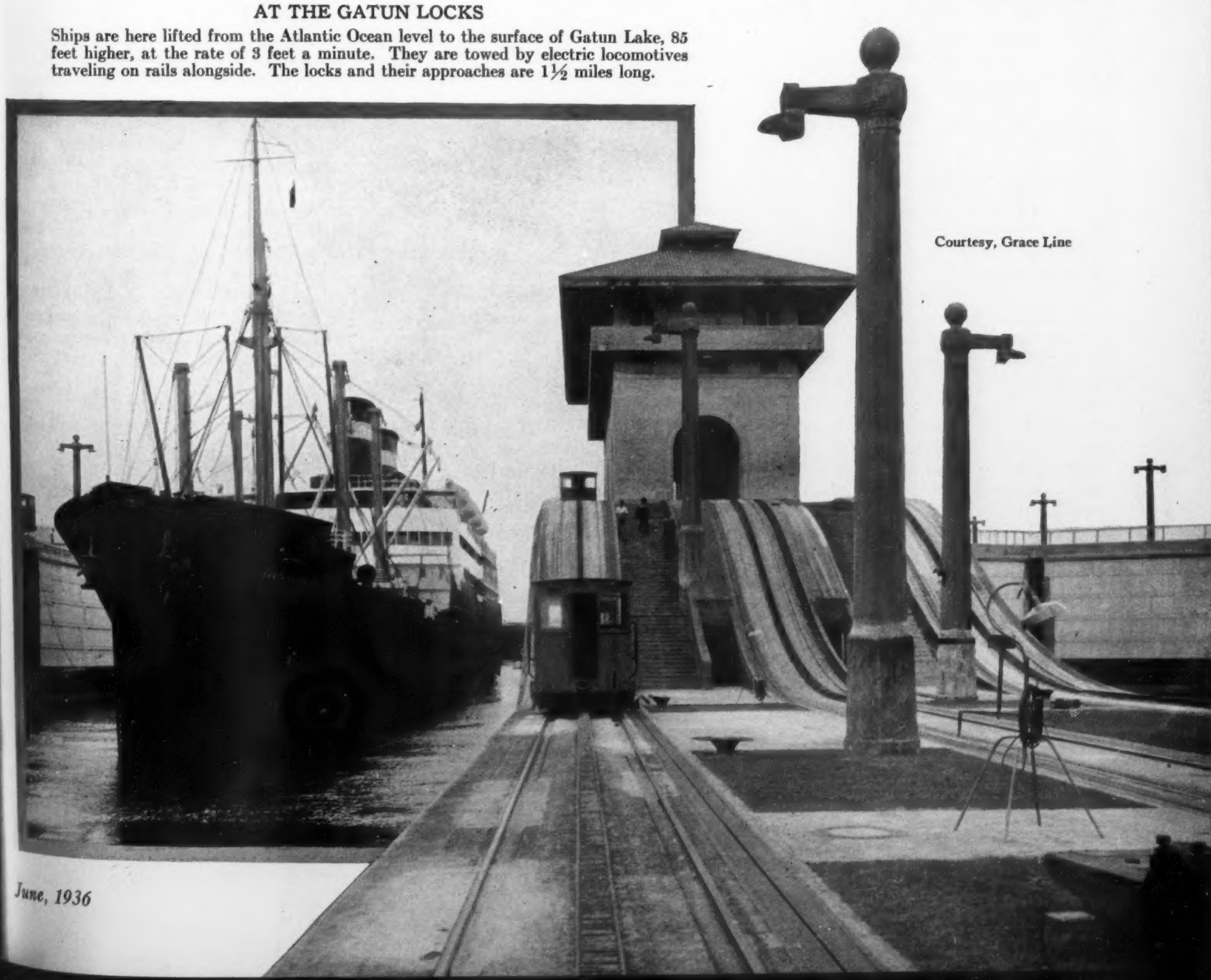
The railroad is one of the principal auxiliaries of the canal, and the story of its construction is secondary in interest only to that of the canal itself. As previously mentioned, roads comprised the sole means of communication between the shores of the Isthmus for three centuries under Spanish rule. At a very early date a paved highway was built from Panama City to Nombre de Dios (established by Columbus in 1502). A little later a similar road was constructed from Panama City to Porto Bello and came to be known as the Camino Real, or King's Highway. Still later another was built from Panama City to Cruces, from which point dugouts were poled or paddled along the Chagres River to the Atlantic Ocean. These highways, traces of which are still to be seen in the jungle, are said to have cost the lives of thousands of natives who either helped to construct them or carried goods over them.

In time, these primitive methods of transportation proved entirely inadequate, and about 100 years ago various nations conducted numerous investigations looking towards the building of a railroad. Eventually it fell to the lot of United States citizens to provide one. The settling, in 1846, of the boundary dispute concerning Oregon, and the ceding of Upper California to the United States in 1848, coupled with the gold discovery in the same year, opened to development a great expanse of land in the West and greatly increased travel. A 12,000-mile boat trip around Cape Horn, or a 3,000-mile journey in a prairie schooner, constituted the only means of established communication, and both were fraught with danger.

In 1846 was signed a treaty by which the United States was given rights of way across the Isthmus of Panama for any routes that she might desire to construct. Two years later, Congress authorized the inauguration of two mail steamship lines, one from New York to Chagres and the other from Oregon and California to Panama, the plan providing for overland transit to connect them. Responsible bidders for the mail contracts were a long time in coming forward, but eventually George Law took the Atlantic end and William H. Aspinwall the Pacific end. Few could fathom how Aspinwall expected to make a

AT THE GATUN LOCKS

Ships are here lifted from the Atlantic Ocean level to the surface of Gatun Lake, 85 feet higher, at the rate of 3 feet a minute. They are towed by electric locomotives traveling on rails alongside. The locks and their approaches are $1\frac{1}{2}$ miles long.



Courtesy, Grace Line

DRILLING NEAR PEDRO MIGUEL LOCKS

A program of improvements, designed to extend over a 23-year period, was initiated in 1924. It includes twelve projects. These views, taken in June, 1932, show the beginning of operations on Project 5, consisting of widening the western approach to Pedro Miguel locks. Drifter drills, on either wagon or tripod mountings, have been employed for many years on this type of work. They receive air from a barge which is equipped with two Ingersoll-Rand electrically driven compressors, each of 1,280-cfm. piston displacement.

profit, but he soon made it known that he proposed to build a railroad across the Isthmus that would cut the overland journey from four days to four hours and greatly shorten the run from Atlantic to Pacific ports, as well as to Australia, China, and the western coast of South America.

Aspinwall interested in his scheme Henry Chauncey, a New York capitalist, and John L. Stephens, who had spent much time in Central America. They entered into a contract with the New Granada Government, agreeing to construct the road within eight years and pledging 3 per cent of the net profits in return for an exclusive concession. The grant was to run 49 years, after which the government was to have the privilege of buying the railroad for $5,000,000. The Panama Railroad was thereupon organized under a charter from New York State, with a capitalization of $1,000,000. Stock was eagerly bought by the public, for since the launching of the venture the California gold strike had been made and investors believed that they would receive a high return upon their money.

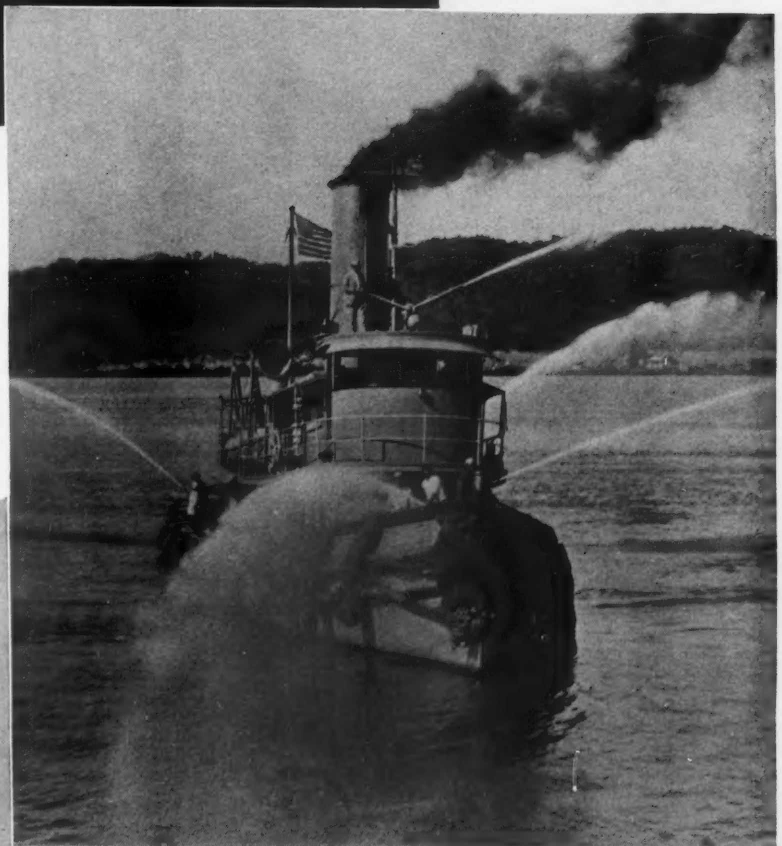
The contract for building the line was awarded to two Americans; but they asked to be relieved of it almost before work on the project had started because the excitement over the gold rush had caused a general exodus of laborers. Thereupon the company took over the work, retaining the former contractors as engineers. The first dirt was turned in May, 1850, on Manzanillo Island in Limon Bay on the Atlantic Coast. Torrential rains, malaria, reptiles, and general jungle conditions proved almost insuperable obstacles from the outset. New groups of laborers were brought in almost weekly; but not infrequently operations just crept along because of a shortage of men resulting from sickness and death. All materials had to be secured from afar. Despite these handicaps, the railroad was completed as far as Gatun by October 1, 1851, a distance of 7 miles.

It so happened that at that time several shiploads of men bound for California were detained on the Atlantic coast because unfavorable weather prevented their making the trip up the Chagres and thence across the Isthmus by the old paved road. They importuned the railroad authorities to transport them to Gatun, and this was done, although there was not a passenger car available. This service became regular thereafter, and the revenue it brought in probably kept the construction work going, for the original capital had been exhausted and the directors were carrying on with their own funds. When word reached the United States that a part of the road was actually operating, confidence in the venture returned and more money was forthcoming.

One interesting minor incident marked this period of the undertaking. A settlement had sprung up on Manzanillo Island at the Atlantic terminal, and in 1852 it was given the official status of a city and named Aspinwall in honor of the founder of the railroad. The local authorities insisted, however, that it should be called Colon, the Spanish form of Columbus, who had discovered Limon Bay. Thus the city had two names for a number of years; but in the end the local government refused to deliver mail addressed to Aspinwall, and the designation was dropped in favor of Colon, which still persists.

By March, 1852, passenger trains were running 16 miles out of the terminus, and by July the line reached Barbacoas, 23 miles out. In the meantime, men and materials had been shipped around Cape Horn and a start made at the Pacific end. Then new troubles arose. The Chagres, which had to be bridged at Barbacoas, was 300 feet wide and subject to sudden rises as great as 40 feet within a single day. A contract was let for the erection of the bridge; but when it was nearly finished it was swept away by a flood. The contractor was bankrupted and the company had to take over the work. Meanwhile labor had again become exceedingly scarce, and agents were dispatched to India, China, and all parts of Europe to recruit new forces. Several thousand men were secured as a result. Among them were 1,000 Chinese. After some of them had died of fever, others developed melancholia because of homesickness and began to commit suicide in large numbers. In the end, only 200 of them left the Isthmus alive.

After a further succession of misfortunes and difficulties, the railroad was finally completed, and in January, 1855, the first train traveled its length of almost 48 miles. But because the work had been done hastily, much of the line already needed replacing. The public, however, insisted on using it, so to gain time for improvements a supposedly prohibitive fare of $25 one way was charged, and 50 cents a mile per cubic foot of freight. These rates failed to drive away trade; and when this was discovered, they were continued and remained in force for twenty years, with the result that the road became a veritable gold mine. It cost $8,000,000, as against an estimated $1,000,000; but by 1865 it has amassed profits of more than $11,000,000. It was not unusual for it to carry 1,500 passengers and the mail and cargoes of three steamships in a day.

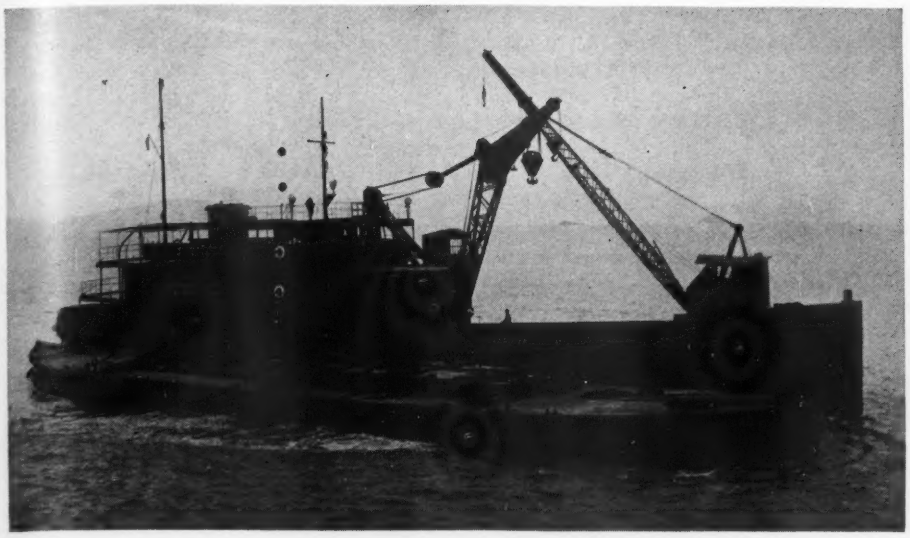


PANAMA-CANAL BOATS

A vast amount of floating equipment is used by the various divisions of the canal administration for operation, maintenance, and improvement. The pictures show three typical small craft. At the top is the U. S. Inspection Launch *Gar*; at the right the fireboat *Cocoli* photographed during a drill in Balboa Harbor; and below is the latest addition to the fleet of tugboats. It is the *Arraijan*, a diesel-electric boat that is equipped with two Ingersoll-Rand 525-hp. engines. A duplicate of the *Arraijan* is now nearing completion at the Government shipyard at Balboa.

DREDGING SAND

Much of the sand required for concrete is dredged from the beach at Chame Point, on the Pacific side. The craneboat *La Valley* is shown at work there. Below is the Prado in Balboa as it appears from the Administration Building.



CRANEBOAT "ATLAS"

This boat is a fairly recent acquisition of the Dredging Division and does general work. It is seen here operating as a suction dredge at the Pacific entrance to the canal. The barge is completely loaded and discharging at three points on the near side.

It was a foregone conclusion that the New Granada Government would take it over under the $5,000,000 agreement when the 49-year charter expired, and to forestall this the company bound itself to pay $1,000,000 in gold, $250,000 annually, and to carry the New Granada mails free in return for being allowed to hold the property. Eventually, however, there was a decrease in business, and in 1879 the assets were sold to the French canal interests for $18,000,000. In 1904 the United States acquired them for $7,000,000. In connection with the canal construction the railroad was relocated and modernized at a cost of $9,000,000. That work is worthy of a story in itself, but lack of space obliges us to omit it. Suffice it to say that by the time the canal was completed the road had earned profits equaling its cost.

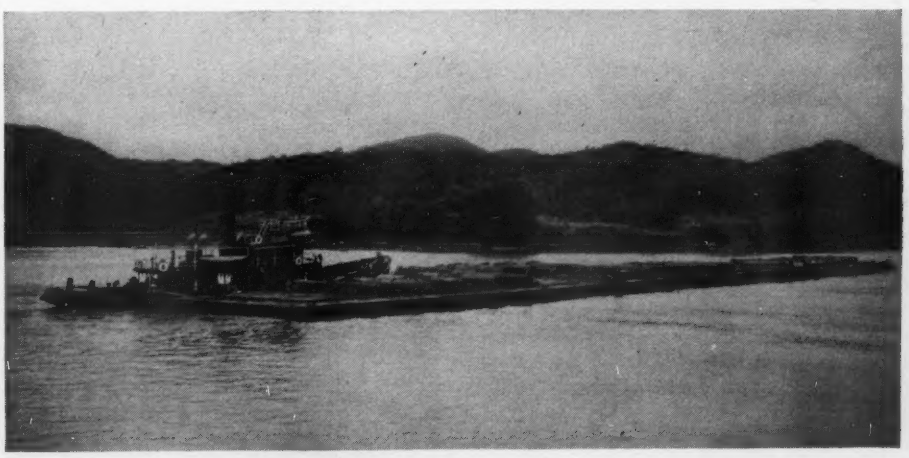
It is this modern railroad, now electrified, over which passengers travel today. An adequate highway never has been built across the Isthmus largely because it would deprive the railroad of much of its patronage. The Republic of Panama has been precluded from constructing such a road because of the treaty provision giving the United States control of all communication along the canal line. However, under a new treaty, this restriction has been lifted and plans are already underway for a 27-mile, concrete highway which will connect with the road that runs to Madden Dam on the Chagres River and continue across the Isthmus to Colon. It will be built by the Panama Road Board at an estimated cost of $3,614,000.

As previously mentioned, Colon and Panama are under the control of the Republic of Panama. Each, however, has an American city as its immediate neighbor. Cristobal is separated from Colon only by Front Street, and Balboa adjoins Panama. Colon Harbor is protected by a breakwater consisting of two rows of concrete blocks measuring approximately 7 feet on the side. The entrance to the canal is nearly 10 miles up Limon Bay from Colon and not far from the entrance to the old French canal. At this end the canal is flanked by Fort Randolph on the east and Fort Sherman on the west, both of which are military strongholds with concealed fortifications. There, also, is the Government's finely equipped coaling station. At the Pacific end is the Balboa shipyard with facilities for handling vessels of almost any size. Many of the boats required for the maintenance and operation of the canal have been built there. On the Atlantic side is a smaller shipyard, the Mount Hope. Included among its equipment are several Class PRE-2 air compressors which have been in service for more than twenty years.

From the romantic standpoint, the canal section affords many interesting sights. Near the Atlantic are the ruins of Porto Bello with old iron works nearby. To the west of the entrance is old Fort Lorenzo which was sacked by the notorious buccaneer Henry Morgan, who survived a career of infamy to become a member of the British peerage. Legend has it that he buried treasure in the vicinity, and the country is full of potholes that have been dug in searching for it. Incidentally, the story of Morgan divulges the origin of the word "buccaneer." It was the habit of the pirates who roved the seas in the seventeenth century to put in periodically at some of the islands along the Spanish Main to secure a supply of beef from the wild cattle that abounded there. The plants where the meat was dried were called *boucans*, and from this word was derived the term by which these sea-raiders have since been known.

The City of Panama likewise holds interest, as it represents the oldest European settlement in the Americas. Close to it are the ruins of Old Panama, which was abandoned following the sacking by Morgan in 1671 and its subsequent destruction by fire. The new city was built by the order of the Spanish Crown with strong fortifications and a wall 10 feet thick and from 30 to 40 feet high. It is related that it was so long under construction and so costly that one day the Spanish king looked out of an upper window of his castle in Madrid with the remark that the wall must surely be high enough for him to see. When the final bills were received, the auditing board caustically inquired whether gold or silver had been used in building the city.

Among the auxiliary structures of the canal may be mentioned the Gatun Dam hydro-electric plant. This is supplemented by a standby plant containing three Nordberg engines which drive 3,000-kva. generators. Ordinarily it is required to be in service during parts of only four months of the year, which is the duration of the dry season. The annual rainfall ranges from 85 to 155 inches at Colon and from 47 to 90



MOVING DREDGED MATERIAL

Broken rock is dredged by 15-cubic-yard dipper dredges and loaded in scows for disposal in deep water. The tugboat *Trinidad* pictured here has five 1,000-cubic-yard scows in tow. Fine material is dreded by suction dredges. By use of a relay-pump barge it is possible to move it through several miles of pipe or to elevate it as much as 175 feet to disposal areas.

FERRYING TROOPS ACROSS

One of the two diesel-engined ferryboats in use at the Pacific end moving wagon trains during army maneuvers. Approximately 60,000 vehicles and 250,000 persons are ferried across the canal annually. A submarine drill boat is seen at work out in the channel.

inches at Panama. The mean annual temperature is 80°F., with a normal low of 68° and a normal high of 95°.

A recent development that will add to the hydro-electric generating period is the Madden Dam. This is a concrete structure built across the Chagres River at a point a few miles upstream from its entrance to Gatun Lake. It is 974 feet long at the crest, and its spillway is 137 feet above the normal river level. There is a generating station in connection with it, and it will also provide storage which will prolong the generating season at Gatun station and will insure an adequate water supply for locking purposes in the canal. A further benefit will be the control of floods which, as already stated, are sometimes sudden and severe. One of the heaviest rainfalls since records have been kept occurred on the Chagres watershed last November, when 45 inches of water fell in twelve days. Although this was greater than its capacity, Madden Reservoir absorbed enough of the flood to prevent any delay in operating the canal and any damage to structures.

As can be readily understood, the maintenance of the canal is a huge task. Despite the breakwaters at either end, an average of 3,000,000 cubic yards of silt is carried into it each year, and this must be removed. The greatest bugbear in this respect is the slide material, principally in Gaillard Cut. Improvement in the alignment of the canal and prosecution of measures to reduce the possibility of slides add to the work that is continually carried on. Figures up to 1930, given in *Dredging on the Panama Canal* by John G. Claybourn, Superintendent of the Dredging Division since the canal has been in existence, are proof of the enormity of these operations. They show that 208,000,000 cubic yards were excavated from within the canal lines during the construction period, while 288,000,000 cubic yards have been removed since then. Auxiliary excavating amounted to 34,000,000 cubic yards during the construction period and to 63,000,000 cubic yards since that time. The total quantity of dirt and rock handled from 1904 to 1930 was 351,000,000 cubic yards.

A characteristic of some of the slides before they actually take place is that the pressure exerted by the loosened material causes a bulging of the bottom of the canal, and this must, of course, be corrected. The most severe slide occurred in 1915 and closed the canal for 216 days. Since 1920 there has virtually been no interference in the operation of the canal from this cause. A general improvement program was inaugurated in 1924 to extend over a period of 23 years and calling for the removal of some 13,000,000 cubic yards of material at a cost of $16,000,000.

To accomplish all this, the canal organization maintains extensive personnel and equipment. Dredging is done with both dipper-type and suction-type boats. Three 15-cubic-yard dipper dredges built by the Bucyrus Company in 1914 and 1915 are still in service. There is a 24-inch suction dredge, *Las Cruces*, powered by four Fulton 1,000-hp. diesel engines. A drill boat, *Teredo No. 2*, equipped with Ingersoll-Rand H-64 piston drills, has served since the canal-construction days, and there is a crane boat, *Atlas*, with two Ingersoll-Rand 400-hp., direct-reversing diesel engines and three Cooper-Bessemer 75-kw. auxiliary units. Two 125-foot tugboats, the *Chagres* and the *Trinidad*, have been in operation since 1927. They have diesel-electric drive, each being provided with two Ingersoll-Rand 480-hp. engines. Two new diesel-electric tugboats, one of which is completed and the other under construction, will be used at the ends of the canal for docking steamers and for general harbor work. They will each be driven by two Ingersoll-Rand 525-hp. engines. On the Pacific end are two ferryboats, each powered by a Washington Iron Works direct-reversing diesel engine. The total value of the equipment of the Dredging Division alone is upwards of $10,000,000.

The labor forces at the Panama Canal are composed of civilians. Their wages are 10 per cent above the prevailing rates for corresponding duties in the United States. The Government maintains commissaries which are, in effect, department stores. By using coupon books, employees and the army and navy personnel stationed there receive 10 per cent discount on all purchases.

The population is naturally cosmopolitan, as the Canal Zone is one of the crossroads of the world. There was an infiltration of many nationalities during the construction period, and some of the foreigners remained. The negro population, for instance, is traceable to the colonies that were transplanted there from Jamaica when the waterway was being built. The canal is the greatest means of support of the people of Panama, both through annual payments for the Canal Zone and through purchases made by visitors and by employees.

Up to June 30, 1934, the United States had spent $564,617,804.65 on the construction, maintenance, and operation of the canal, and an additional $42,457,041 for fortifications. Receipts up to the same date were approximately $380,000,000.

The Governor of the Panama Canal is Col. J. L. Schley. The Superintendent of the Mechanical Division is a naval officer, Com. Charles Osborne. He has charge of the shipyards. As already mentioned, John G. Claybourn is Superintendent of the Dredging Division.

COALING STATION

This plant at Cristobal is thoroughly modern. Two reloaders are shown transferring coal from railroad cars to two ships.

When All Roads Led to Rome

William S. Powell

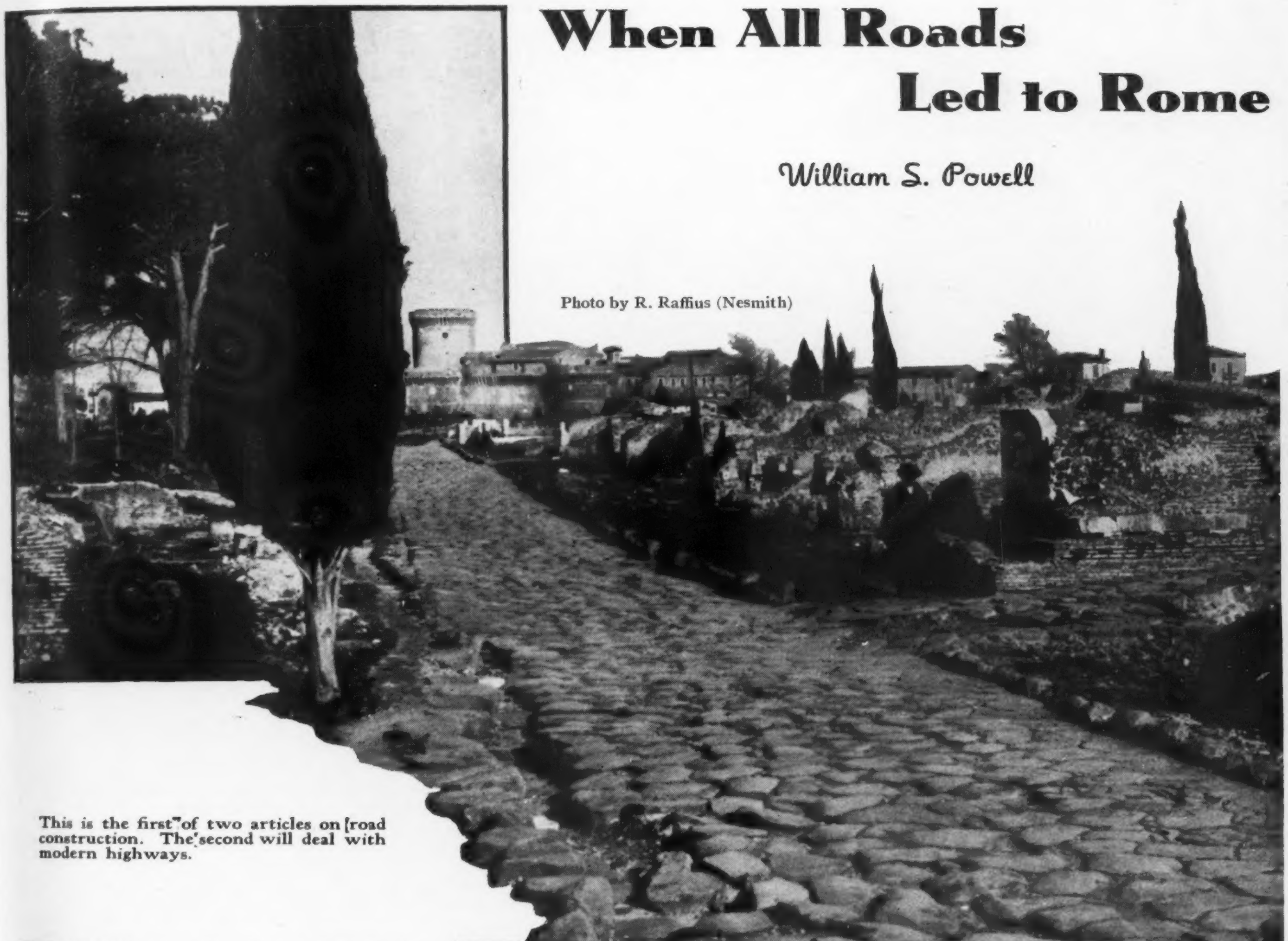
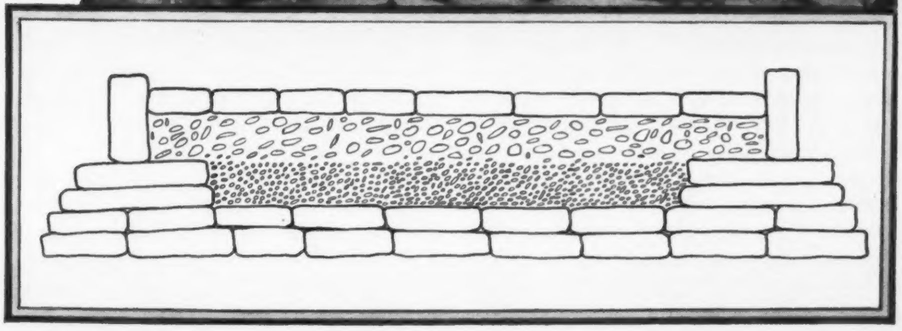


Photo by R. Raffius (Nesmith)

This is the first of two articles on road construction. The second will deal with modern highways.

HISTORY has taught us that road-building and the march of civilization go hand in hand. The greatest road-builders in ancient times were the Romans. The Roman Empire fell after it reached its cultural peak, and with its fall its roads went into decay and remained so for the next 1,000 years. When interest in highway construction was finally revived it came, strange to say, not from Rome but from France and England.

Savage peoples built no roads because, with their primitive mode of living, they had no need of them. Their wants were few and, for the most part, individual. Their wanderings were limited, in many instances being restricted to one small area. Wheeled vehicles were unknown, and narrow paths sufficed. These were probably game tracks or natural trails. It is unlikely that attempts were made to improve them, and they became well defined only through continued use. Those leading to water holes undoubtedly saw the most service. Conflicts with neighboring tribes gradually led to the blazing of war trails through the forests. As civilization advanced, the needs of the people became greater and more collective. Man came to think of himself not merely as an individual but as a member of a group. Footpaths no longer adequately met his expanding interests, and he began to construct roads.



HOW ROMAN ROADS WERE BUILT

The typical Roman road was from 16 to 36 feet wide and up to 3 feet thick. It consisted of four layers, the upper and lower ones being of large rocks and the intermediate ones of smaller rocks bound with mortar. The curbs alongside rested directly upon the lower course. The picture at the top shows a section of the Appian Way, which was named after Emperor Appius Claudius Caecus under whose reign it was begun. It originally ran to Capua, but was later extended to Brindisi, a distance of 360 miles from Rome. This picture clearly shows the large stones of the top course.

It is not known precisely when road-building started, for documentary evidence on the subject is not available. We can only observe the remaining traces of those ancient highways and speculate as to what took place centuries ago. We are quite safe in saying, however, that the rearing of such massive structures as the pyramids and the great walls and hanging gardens of Babylon required roads if for no other reason than to transport the necessary materials to the sites.

We are told by Herodotus that a great king of Egypt built a road across the sands to transport materials for the pyramids, and that this road was 10 feet thick in places, was of massive stone blocks, and lined on both sides with mausoleums, temples, and statues. Early historians inform us that as far back as 2000 B.C. roads radiated in all directions from Babylon and extended as far as Sasu, Ecbatana, Sardis, and Nineveh. The ancient Persians, Assyrians, Carthaginians, Chinese, and Peruvians also are known to have constructed fine roads.

Photo by E. F. Ouellette (Nesmith)

RUINS OF A BRIDGE

Section of a structure erected by the Romans at Asa Pazar in Turkey.

PRINCIPAL ROADS OF ROME

Seven famous "ways" radiated from the central city to the various parts of what is now Italy. They were built primarily for military purposes by various emperors during the pre-Christian era.

The Carthaginians were probably the first systematic roadbuilders. In China, waterways were developed early in its history and used extensively. Its longest road was constructed in the third century as a defense measure. It was 15 feet wide and 2,000 miles long and ran on top of the great Chinese Wall. The Incas of Peru are said to have been the first roadbuilders in America. Their roads were constructed before the Spanish conquerors landed in 1527, and they represented a tremendous amount of labor and not a little engineering skill, stretching as they did for miles through mountainous country.

In Europe, so far as is known, the Romans set the pace in roadbuilding. The rulers of that great empire knew that roads were vital to peace as well as to war, and that their people could be united and held together only by adequate means of communication. Despite the crudeness of their construction methods, they undertook gigantic highway projects and completed them over a period of years. Traces of their work are still to be seen in many parts of Europe. A number of the old roads are in use today, having been resurfaced with modern materials and by modern means, while many existing highways follow in part the routes laid out in those far off days.

When Rome was in her glory, a great network of roads covered the city, and 29 highways, having a total length of approximately 50,000 miles, radiated far and wide from her gates. These helped to link her with the centers of the empire—Alexandria, Jerusalem, Damascus, Antioch, Ephesus, Constantinople, Athens, Naples, Lyons, Paris, Dover, Canterbury, London, St. Alban, and York, all of which were interconnected by a system of roads and waterways along which post service was maintained.

The army, aided by the conquered nations, did most of the work. The roads were anywhere from 16 to 36 feet wide and about 3 feet thick, and have been described as huge walls laid on their sides. They were constructed in four layers: the first was of rough stones, the second of smaller ones in mortar, the third of mortar composed of gravel and coarse sand, and the fourth or wearing course was made up of large, flat stones polygonal in shape and placed close together. High stone curbs were built up from the bottom course on both sides.

The Romans knew the advantages of adequate drainage, although their methods of effecting it were cumbersome. The main highways were raised in the middle by means of arches and stonework—the rise being about 6 inches in every 16 feet. This high crown permitted the water to run off and brought the projecting hubs of the chariot wheels above the tops of the curbs, thus preventing them from coming in contact with them. Side drains were provided at intervals. An unusual thing about these roads was the fact that they were almost always built in a straight line, although curves would have involved less labor in many places. Milestones were set 1,000 Roman paces apart along the highways.

It is very interesting to study in detail the construction of these early roads. Where possible, the ground was excavated until a solid foundation was reached. Upon this was placed a bedding course of sand, from 4 to 6 inches thick, or of lime-and-sand mortar about 1 inch thick. The first course or *statumen* was laid on this bedding, and consisted of two layers of flat stones cemented together with lime mortar. When lime was not available, clay was used. The *statumen* varied in thickness from 10 inches in good ground to 2 feet in unstable ground. Any kind of stone was employed, as the purpose of this course was to provide a solid base. The stones were placed by ordinary masons, and a chisel and mallet and iron wedges, or a saw, were used for cutting them. To lay the heavier stones they were suspended by cords from poles

passed over the shoulders of the workers, and a crowbar served to move them into position.

The second course or *rudus* was of broken stones smaller than those in the first course and bound with lime. The usual proportion was three parts of stone to one part of thick lime, but when the aggregate came from old buildings, then two parts of lime was used to five parts of stone. A rammer was employed to consolidate, smooth, and level this layer, which was about 9 inches thick in its finished state. The third course, commonly called *nircleus*, was a mortar made of gravel and cement or of coarse sand and lime. It was placed in several layers and graduated in thickness from an inch at the sides to 1½ inches at the center. Each layer was compacted with a roller.

The top course, or the *summa crusta*, corresponding to the wearing course of our modern highways, was bedded in the freshly laid third course. It consisted of hard, wear-resisting stones in the forms of pentagons, hexagons, or irregular polygons which were from 1 to 3 feet in diameter and about 6 inches thick. The upper surface was smooth, but the underside was left rough. The stones were fitted one against the other. Occasionally such a road was surfaced with concrete.

There were, in all, seven main highways which began at the gates of Rome. The Appian and Latina ways led southeast, the Salarian, Valarian, and Flaminian northeast to the Adriatic; and the Cassian and Aurelian to the northwest. Of these the Appian Way is probably the most celebrated. It was begun in 312 B.C. by Appius Claudius Caecus and led across the Pomptine Marshes to Capua, 142 miles away. It was later extended to Brundusium (Brindisi), a total distance of 360 miles. Julius Caesar is said to have completed it. Branching off from it at various points were the Setina, Domitiano, Compana or Consularis, Aquillia, Trajana, and Manucia or Numicia ways.

The Flaminian Way was the most important northern road and led from Rome to the Po Valley, the Alps, and the Roman colonies beyond. It was built by Caius Flaminius the elder during his censorship, and extended for about 222 miles through Etruria and Umbria to Ariminum, now Rimini, on the Adriatic. It crossed the River Nar about 60 miles from Rome over a great stone arch bridge the central span of which was 150 feet wide and had a rise of 100 feet. In later years this highway was continued under another name, that of Aemilia, and traversed Gallia Cisalpina to Placentia, where it crossed the River Po and finally reached Milan.

The Latina Way extended from Rome to Beneventum, the focal point of a number of roads. Branching from it were the Tusculum, Labicano, Praenestina or Gabina, and the Collatina ways, the last of which was very short. The Salarian Way went from the Colline Gate in Rome to Ancona via Reate, Asculum, and Firmum Picenum. It was one of the oldest in this group, and its most important lateral was the Caecilia Way.

The Cassian Way traversed central Etruria via Veii, Arretium, and Luca *en route* to Luna. Just before reaching Luna it met the Aurelian Way. One of its branches, the Cimina Way, crossed the Mountains of Viterbo. The Aurelian Way left Rome by the Janiculum Gate, touched Alsium, Populonium, and Vada, and continued to Genoa. Taking off from it were the Portuensis Way, which followed the right bank of the Tibur to Portus Augustus, and the Ostiensis Way, which followed the left bank to Ostia where it turned to the south and ran along the coast of the Tyrrhenian Sea to Terracina.

The Tiburtina Way led from Rome to Tibur and continued thence under the name of the Valerian Way, touching Treate, Aternum, and Truentum. The first Roman paved street of which we have any knowledge extended from the Temple of Mars in the City of Rome to the Porta Capena and the second from that temple to the Campus Martius.

These ancient roadways, which started at Rome, eventually spread over all Europe. They reached in every direction and were continued even beyond the continent in Briton, later called England. Briton was invaded by the Romans in 55 and 54 B.C. The inhabitants led a self-supporting existence, eating what grew naturally around them. Caesar found most of them clothed in skins. Records of the beginnings of road transport in that country give us an inkling of its effect on the lives of the people. With intercourse thus facilitated, travelers soon

OUR COVER PICTURE

A VIEW of an excavated street in Pompeii that is essentially as the Romans last used it. In the foreground is one of a series of stepping stones, ostensibly for the use of pedestrians in crossing. On either side of the center stone can be seen the furrows worn by the wheels of countless chariots.

OLD ROMAN BRIDGE

This massive masonry structure crossed the Sakaria River in Turkey. It was on the main highway leading to the East over which the Roman troops marched to the Persian Wars. The stream has since changed its channel, leaving the bridge high and dry.

Photo by Margaret Willis (Nesmith)

ROADS AND TOMBS

In many instances there was close association between ancient highways and burial places. At the right is a road in Siracusa, Sicily, that was evidently hewn from solid rock. The flanking walls housed tombs. Below is the tomb of Caecilia Metella and the old Roman road leading to it.

Photo from Calcium Chloride Association

Photo (C) by R. Raffius (Nesmith)

learned something of the country's mineral wealth. Tin was probably the first metal to be worked. It was of use to the Greeks and Romans in making bronze. We are told that the Phoenicians came by sea to Cornwall for tin and that it was also carried overland to ports like Colchester, and thence by water to the Baltic, one of the destinations of European caravans. In exchange for their tin the Britons received from the continental traders articles which they lacked, such as woven linen, woolen goods, and beads. By this interchange of products the ancient Britons became, to quote the words of Caesar, "somewhat civilized."

The roads of Briton, unlike those of the Romans, had many curves, since they followed lines of least resistance. Many of them were built along the ridges of the chalk downs because they offered the easiest routes from the standpoint of construction. The Icknield Way along the Chiltern Hills, and the road from Guildford along what is known as the "Hog's Back," were of this type. If they did not follow chalk outcrops they traversed gravel routes, and traces of some of the latter can still be seen.

For the work of improving the Briton roads, the Romans depended upon the materials at hand. As hurdles daubed with clay were used by them in building houses, it is probable that they recognized their value in highway construction and laid them in unstable ground to prevent pack horses or chariots from becoming mired during wet weather. Wood was employed for building bridges, timber alongside streams being cut for the purpose and floated down to the sites. Shingles were used to roof over those structures—a practice which prevailed also in other countries.

Roman roads brought the evils as well as the benefits of civilization to primitive peoples, as fancifully brought out by Anatole France, in his story about the penguins whose morals, so he wrote, began to be corrupted when transportation brought to them the first ladies' garments. While Rome held sway, the inhabitants of all western and southern Europe, Asia Minor, and North Africa enjoyed the advantages of travel abroad and the exchange of ideas and commodities with their neighbors. In short, the civilizing power of the Roman roads was felt throughout the known world.

Those that overran the Roman Empire apparently did not appreciate the importance of highways, for they did not maintain them, with the result that during the Dark Ages transport again became difficult. King Harold's army was able to march at the rate of only 18 miles a day from Stamford to Hastings to fight William the Conqueror. Later the crusaders journeyed across Europe and Asia Minor into Palestine, accompanied by wheeled vehicles. Prisoners of war were often turned into beasts of burden. In the Middle Ages roads were far from good, and the streets were narrow and without sidewalks.

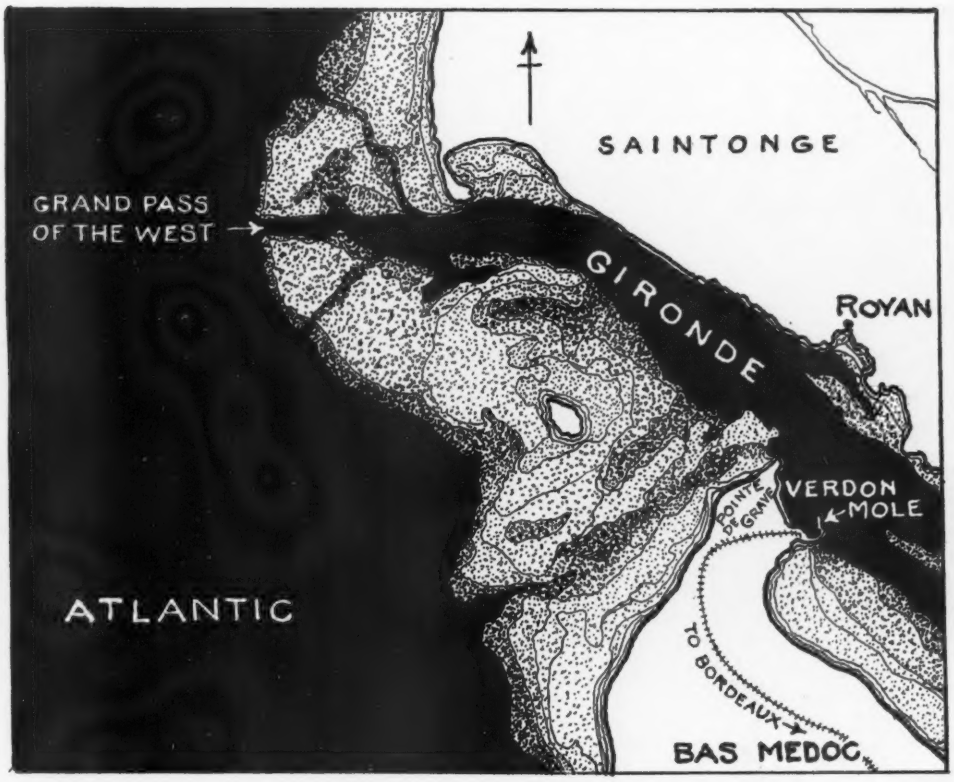
For more than 1,000 years after the decline of the Romans, roadbuilding was a lost art. There was little commerce during the Middle Ages, and less travel. France, England, Germany, Italy, and Spain were petty kingdoms struggling for recognition. With the exception of the wars of the Huns and the Goths and the Vandals, who swept across Russia and Western Europe, the conflicts were mostly local. No great empire had arisen which required a network of highways to connect its territorial possessions. Existing communities were largely self-sufficient, and most of the countries were not compelled to rely on foreign importations for the necessities of life. What manufacturing was done was merely for local consumption, and the limited transportation facilities met the needs of a population that was more than 80 per cent rural.

Most of the roads during this period were little more than cart tracks. Passenger transportation was principally by horse-drawn carriages, and individuals generally traveled on foot or on horseback. With the exception of the centers of the towns, no effort was made to pave the roads. In England, the highways were neglected for centuries after the Romans departed.

Four great roads were built by the Romans on English soil, and they are still used today although they have undergone great changes since that time. The best known of these is the Great North Road, which goes from London through Lincoln, York, Newcastle, Berwick, and Edinburgh. James I came down this highway to be crowned king of England in 1603, and Ben Jonson is said to have walked its length to Edinburgh.

The Great West Road follows the Thames River from London and runs by way of Reading to Bath and Bristol and thence, by water, on to southern Ireland. The Dover Road extends southeast from London to Rochester, Canterbury, and Dover and, on the other side of the channel, continues on the continent. In his *Canterbury Tales*, Chaucer refers to this highway as the scene of many pilgrimages from London to the Shrine of St. Thomas Becket at Canterbury. The last of this group is the Watling Street Road which leads northwest out of London to Litchfield and Chester, not far from Liverpool. It was the latter route that Dr. Samuel Johnson and David Garrick are supposed to have taken from Litchfield as young men to seek their fortunes in London.

During the Elizabethan period the highways of England were more or less traversable. Shakespeare in his works refers continually to them in connection with the "post system" which was then maintained and by means of which royal letters and messages were sent from place to place, the citizenry paying dearly for the privilege of using the service. The coaches were drawn by horses and corresponded to the stagecoaches of early American days.



WHERE WORK WAS DONE

The Gironde estuary that forms Bordeaux's gateway to the Atlantic. The stippled areas represent submerged sand bars that prevent the passage of ships. The location of the new channel, Grand Pass of the West, is indicated, while the dark-colored angling lines above and below it represent older channels that became too clogged for use by large vessels.

Bordeaux Builds a New Outlet to the Sea

R. G. Skerrett

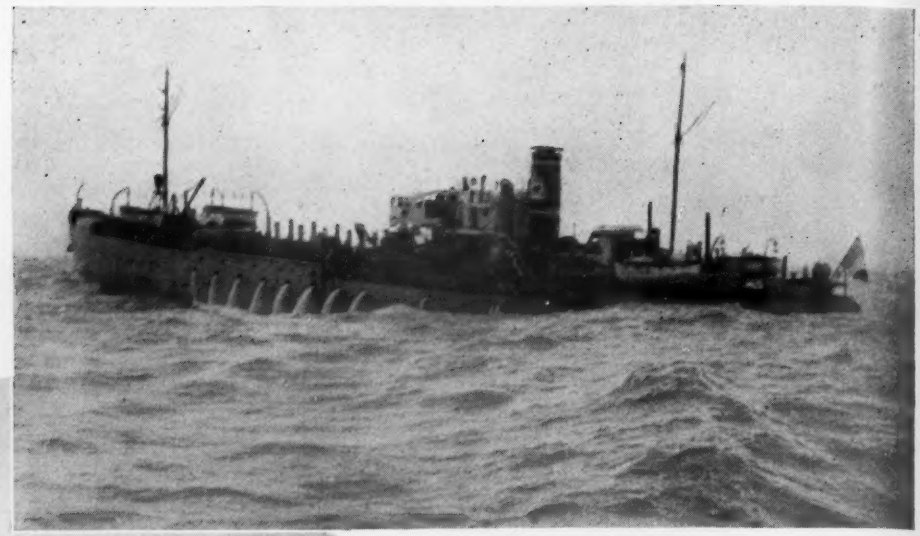
BORDEAUX today has a new outlet to the sea that provides a passageway for the largest of ocean-going liners. That new link between the open Atlantic and the mouth of the Gironde was dredged despite the fact that many eminent experts declared that it could not be done; and by that outstanding achievement the engineers of the Port of Bordeaux Authority have again displayed their resourcefulness in dealing with extremely difficult conditions interposed by nature.

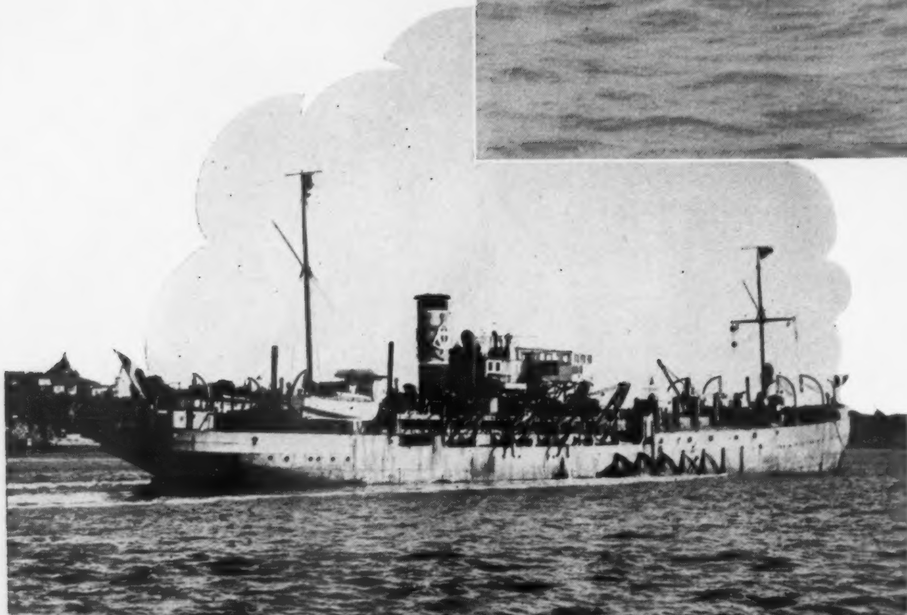
The Gironde is a great land-locked estuary that lies between the Atlantic and two tributary rivers, the Dordogne and the Garonne. On the latter Bordeaux is located a little more than 60 miles in from the sea. Until recently, all vessels trading with Bordeaux had to make the inland run, which was not infrequently hampered by tidal stages or atmospheric conditions. Therefore, the port authority called into being the Verdon mole just inside of Pointe de Grave at the mouth of the Gironde and connected it by rail with Bordeaux.

The mole, which was described in the September, 1933, issue of this Magazine, is situated where deep-drafted transatlantic steamers can dock safely, thus facilitating the rapid movement of passengers, postal matter, and express shipments to and from Bordeaux. This improvement was necessary in order to enable that city to maintain her enviable position as the third largest seaport in France. But, having constructed the mole, the port authority was confronted with the disquieting fact that neither of the existing channels extending offshore to the open sea could meet the requirements of present-day and prospective maritime commerce.

In the course of untold centuries, the ebbing waters of the Gironde have carried seaward an enormous volume of solid matter that has gradually built up offshore an ever-widening and rising submarine plateau composed mainly of sand and gravel. One winding, shifting channel of unstable depth follows the north coast of the approach to the Gironde from the sea, and a second channel traces its course in a southwest direction across the great submerged bank. The latter natural channel is navigable under the guidance of a qualified local pilot only when the state of the sea, the tide, and favoring wind permit. Notwithstanding the interior improvements of the port, the responsible officials were face to face with the fact that nature threatened to close the gateway to the sea by rendering the existing channels too shallow and too winding for use by ships of modern large dimensions and high speed. Its salvation lay in providing a new channel directly across the broad sand bar, and this meant working virtually in the open sea and in relatively shallow water where frequent strong winds were certain to produce fairly high and quick-following waves. Such was the problem confronting the Port of Bordeaux Authority a few years ago.

Competent critics were sure that the desired channel could not be dredged, and others were equally certain that the channel if dredged would soon refill. Still another group of experts was convinced that the winds of the region would make dredging possible only for a limited number of days annually, and, by implication, that dredging and maintenance would entail prohibitive outlays and unreasonable delays. Undismayed by this discouraging attitude, the engineers of the Port of Bordeaux Authority believed that a suitable





IN CALM AND IN STORM

Two views of the seagoing suction dredge *Pierre-Lefort* which the Port of Bordeaux Authority built to open a new passageway to the sea. In the upper picture the vessel is seen operating under conditions that would have stopped any other dredge.

channel could be dredged; and they set about preparing a plan of action and creating facilities capable of battling with nature's opposition.

First, they made intimate surveys of the offshore bar and discovered just how the materials of that obstructing body were distributed. They also ascertained that depths over the bar changed very slowly from year to year, and that the sand and gravel were generally so arranged and compacted as to give the barrier a high measure of stability even though superficially exposed to strong currents and to the frequent sweep of stormy winds. The engineers reasoned that nature could be overcome provided a deep and broad channel could be dredged at a rapid rate with the axis of the channel in line with the average movements of tidal currents and prevailing winds, thus utilizing these forces to help keep the channel clear after it was dug. Such was the broad strategy of the scheme.

The next problem was to devise a dredge that could work offshore and carry on day in and day out unimpeded by a considerable seaway and fairly swift currents—in short, a type that would be superior to anything previously evolved and capable of carrying on under far harder conditions than vessels in that field of service had ever been called upon to meet. Again, the French engineers resorted to research and to mastering each phase of their problem before settling definitely upon the dimensions, the main features, and the primary source of power that were to render the craft not only efficient but economical in operation. Many months of study and testing led to the sea-going dredge *Pierre-Lefort*, which has demonstrated her fitness for the work assigned her and has given to the harbor engineer a unique and valuable aid.

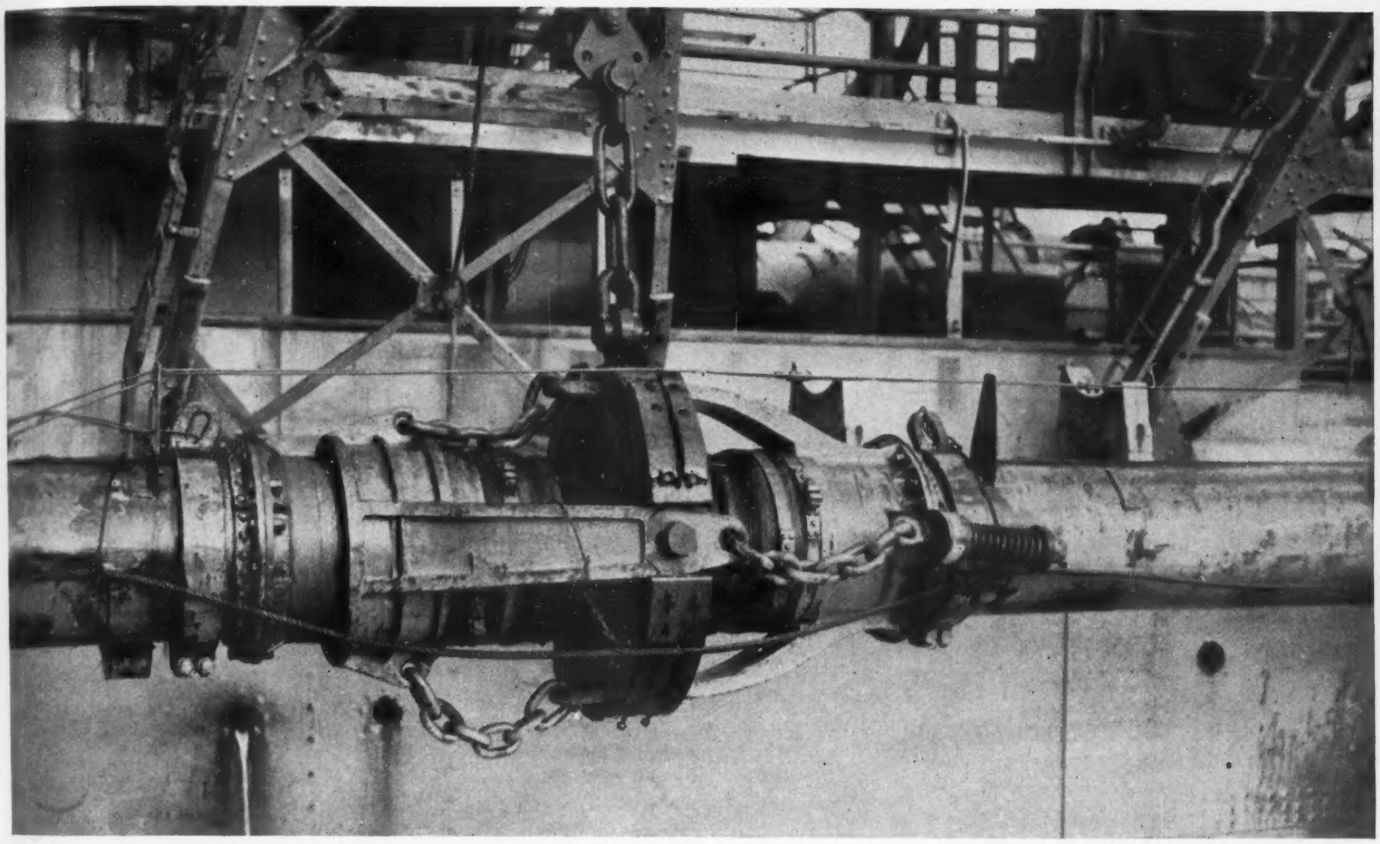
In the experiments which preceded the building of the *Pierre-Lefort*, use was made of the steam-driven dredge *La Coubre;* and this older craft, so far as she permitted, was modified in accordance with those investigations so that she could collaborate under favorable conditions with the *Pierre-Lefort* in dredging the new channel. She could not, like the latter, operate when sizable seas were running, but she did help, and to that extent afforded a basis upon which to compare performance costs.

The *Pierre-Lefort* is a steel-hulled vessel that has a length of 337 feet between perpendiculars, a beam of 54 feet, a maximum draft of 20 feet, and a spoil capacity of 2,620 cubic yards. She can fill her sixteen cargo compartments by means of her powerful suction pumps in about 50 minutes, after which she moves to a suitable point in deep water where she discharges her load. Each compartment has release gates that are positively operated by vertical hydraulic pistons, with the result that the gates do not bang and damage themselves or their seatings when the craft is rolling or plunging.

In the course of 24 hours of continuous operation, the *Pierre-Lefort* can dredge and dispose of 39,238 cubic yards. She is fitted with two suction pipes, one on each side, and these are long enough to enable her to do effective work in water up to 65 feet in depth, although most of her dredging up to date has been in shallower marine areas. She can move over the water bed at a speed of 2 knots an hour when dredging against a current running at 5 knots, her propelled speed, therefore, being 7 knots. When running free, with her suction pipes raised, the *Pierre-Lefort* can make a maximum speed of 11 knots an hour. It takes her only five minutes to discharge a full load of spoil; and this facility, in combination with her speed of propulsion, enables her to load and to discharge many times a day.

One of the prime reasons for the success of the *Pierre-Lefort* in her offshore work lies in the make-up of her two suction pipes, each of which has a diameter of nearly 25.6 inches and a total length of approximately 90 feet. These pipes trail rearward as the vessel advances when dredging, their suction intakes or nozzles resting on the sea bed and being dragged over it the while. Each nozzle is a large fan-shaped hollow casting of steel that maintains close contact with the water bed by reason of its weight, and it does not have to bury itself in the bottom to dislodge and to dredge sand, gravel, or mud.

It is understandable that the suction



SUCTION-PIPE JOINT

Details of one of the flexible couplings of the suction pipe that enable the craft to operate in rough seas.

pipes must be sufficiently flexible to permit the dredge to ride in a seaway without the danger of setting up damaging stresses at the connecting points between the suction pipes and their pumps, and that the nozzles must, at the same time, be free to accommodate themselves to the changing contours of the sea bed. This flexibility has been assured in the following manner: The upper end of each suction pipe has a swivel joint, which connects with the pump intake. That joint is broken when the pipe is hoisted up and laid on deck when not in use. Interposed between the four rigid steel sections that constitute a suction pipe are two ingeniously designed semi-flexible joints and a single ball joint—the latter giving the dredging intake free play vertically through a range of 40°. At four points between its two ends, the pipe is suspended from tackles attached to four strong catheads or cranes—the lines of the four tackles leading to winches by which the pipe can be lowered into the sea or lifted aboard.

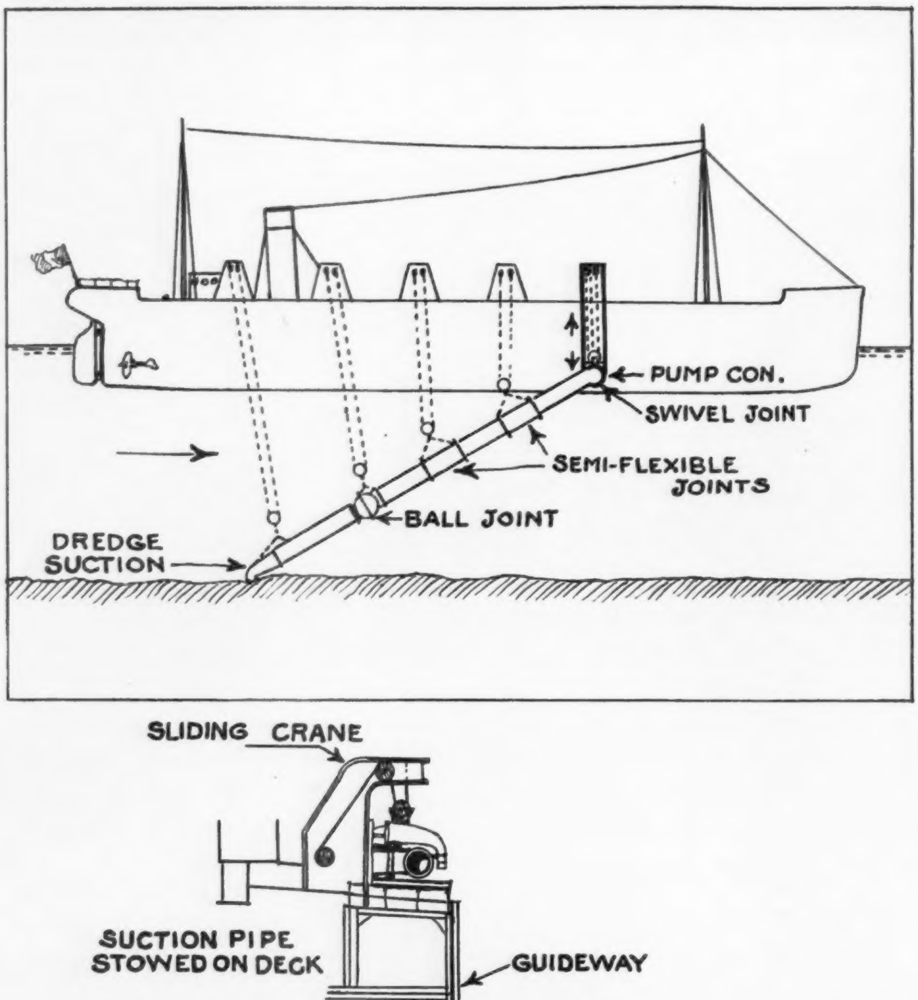
The flexible connections are the outcome of much experimenting and wide experience, and they made it possible for the *Pierre-Lefort* to keep right on dredging in seaways in which the waves had a height, between hollow and crest, of as much as 13.12 feet! This seaworthiness enabled the craft to stick to her task day and night; and during one year she operated offshore for 200 days to the great astonishment of the Doubting Thomases that had not believed such a record even remotely possible.

The *Pierre-Lefort* is equipped with two suction pumps, each driven by a 650-hp. electric motor. She has twin screws, and the electric motor on each shaft has a capacity of 1,150 hp. Her primary source of power consists of three diesel engines, two of 1,400 hp. and one of 1,800 hp. There are two 25-hp. auxiliary diesel engines, and another diesel of 300 hp. for certain auxiliary generators. In fact, all oil engines drive electric generators which, in turn, furnish current for lighting, pumping, hoisting, propulsion, and for ventilation and other minor services. Motors of 250 hp. each are installed to operate the pumps that were designed to supply high-pressure water for jetting purposes at the suction-pipe intakes; but this action was not required to break up the bottom formation so that it could be drawn inboard by the suction pumps. The vessel possesses considerable reserve power, making it possible for her to meet any emergency that might cripple any part of her generating system; and the propelling generators and the pumping generators can be switched to the opposite service, if need be. Both the operation of the pumps and the propelling of the craft can be directed from her bridge.

In excavating the new offshore approach to the Gironde, officially known as the Grand Pass of the West, the *Pierre-Lefort*, assisted by the dredge *La Coubre* when weather was favorable, dredged a total of 13,011,944 cubic yards of material during the 3-year span in which the entire work was done. The finished channel is 2.8 miles long, 3,280 feet wide, and from 29.5 to 32.8 feet deep at low water. The passageway has remained virtually constant in its dimensions since its completion, thus proving the wisdom of the preliminary work done by the engineers of the port authority and confirming their faith in the permanency of a channel excavated along the course chosen by them. The powerful pumps that did the dredging induced a flow through the suction pipes varying from 21.32 feet to 26.24 feet a second, and that movement was strong enough to pick up from the sea bed and to deliver into the spoil compartments pieces of rock more than 17 inches long and cobbles close to 6 inches in diameter.

As Monsieur Francois Levêque, chief engineer and director of the Port of Bordeaux Authority, has expressed it: "The obstinacy and the audacity of the engineers have therefore triumphed over the opinions of experts . . . . The director of the port and his engineers decided to execute the work and to defy the winds and the tides. It was not just risking a throw of the dice: the decision taken was, on the contrary, the outcome of very important and very precise surveys made on the spot, which were afterwards coördinated and utilized methodically by young engineers who were energetic and animated by a truly flaming zeal."

It will be recalled that the older and smaller *La Coubre* was also equipped with suction pipes similar in their get-up to those of the *Pierre-Lefort*. That dredge is capable of carrying a maximum spoil load of 1,962 cubic yards; her free speed is 2



ARRANGEMENT OF SUCTION PIPES

The dredge is equipped on each side with a suction pipe that is 90 feet long, 25.6 inches in diameter, and jointed to give it flexibility. The top sketch shows how the pipes are suspended at four points during operations by means of lines running to hoists mounted on deck. When the vessel is not dredging the pipes are stowed aboard, as illustrated in the center. At the bottom is seen one of the suction pipes connected to the intake of the dredging pump, ready for work.

knots less than that of the *Pierre-Lefort;* she is not so seaworthy; and her speed when dredging is not sufficient to enable her to work against a fairly strong current. The *Pierre-Lefort* carries enough fuel oil for her diesel engines to last for an active period of two weeks, while the steam-driven *La Coubre*, which burns naphtha residue under her boilers, has to refuel every four days. These operating factors have a direct bearing on the performance costs of the two dredges. The higher-powered *Pierre-Lefort* has a lower fuel consumption than the *La Coubre*.

The annual cost of each dredge, on the basis of nine working months per annum and not including certain charges that would have to be added for commercial service, has been estimated by the port authority on the basis of 1 cubic meter (1.3079 cubic yards) of excavated material delivered in a spoil compartment, and amounts to 0.65 franc for the *Pierre-Lefort* and to 0.97 franc for the *La Coubre*. A contractor doing the same work with the same vessels would have to charge twice as much to make a profit. Nevertheless, a dredge of the same qualifications as the *Pierre-Lefort* would permit him to operate under conditions and at points that would have prohibited dredging in the past.

Because of the enterprise shown by the Port of Bordeaux Authority, the *Pierre-Lefort* and the *La Coubre* were available when it was necessary to deepen the estuary of the Loire so that the great French liner *Normandie* could make her way from the shipyard at Saint-Nazaire on her first run into the open Atlantic last year. The task of suitably deepening the channel entailed the dredging of approximately 5,231,600 cubic yards and of carrying the excavated material to a dumping point nearly 6½ miles offshore. A considerable section of the new channel traverses an area often swept by rough seas, and there it was that the *Pierre-Lefort*, particularly, functioned to advantage. The two dredges completed the job within the remarkably brief span of seven months, despite decidedly boisterous weather at times. Both the *Pierre-Lefort* and the *La Coubre* have shown that they can dredge mud or sand very efficiently, and a mixture of sand and mud at a slightly reduced rate of output. The successes at the entrance to the Gironde and at Saint-Nazaire will undoubtedly lead to similar work outside the Port of Havre and in the Port of Toulon.

Notable as have been the channel dredging operations in connection with the coastal harbors of the United States and the seaports of other nations, the diesel-electric *Pierre-Lefort* represents a marked advance in an admittedly difficult department of harbor work, and the world at large will, undoubtedly, profit by the pioneering of the experts of the Port of Bordeaux Authority. This article would have been impossible but for the generous coöperation of Monsieur Francois Levêque, director of the foregoing organization.

Saving Oil Wells by Air Pressure

J. R. Cozzens

NOWHERE else in the oil-producing industry does air pressure play a more important part than in the forcing of water from oil-bearing rock. This process, considered almost a miracle in 1920, is now a regular feature in the oil fields of Ohio, West Virginia, and Kentucky, and by means of it hundreds of valuable wells are being saved and reclaimed.

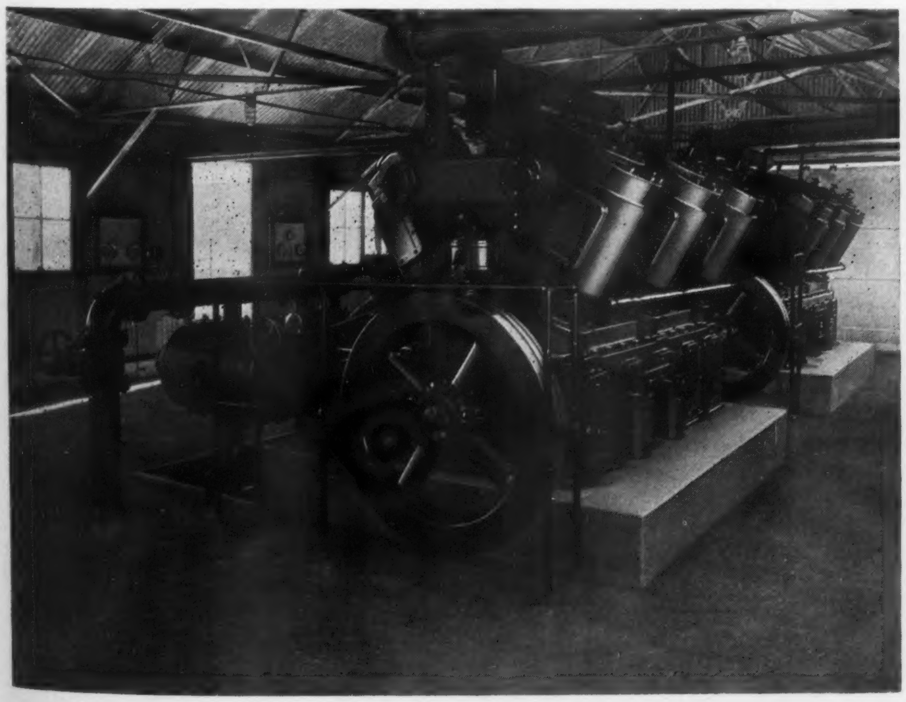
Of all known agents, fresh water is the most destructive to oil-bearing sands. Its presence has accounted for thousands of ruined wells and for countless miles of damaged territory. Control measures are complicated by reason of the fact that certain oil sands hold water; and in many fields there is a continual seepage of water into the sands because of improper plugging of abandoned wells. Under such conditions the only recourse is to drain the sand of its accumulation of water; and the only method that has proved successful in all fields is controlled air pressure.

Air pressure was first applied in those fields in 1915 for the purpose of driving oil through sands where the natural rock pressure was exhausted. It was initially tried on wells that had been ruined by water. After they had been subjected to pressure for some time, certain of the wells were opened, and shortly afterwards operators were surprised to find that they contained oil instead of water. When the oil was withdrawn the water returned, but often in lesser quantities. Air was then introduced at regular intervals, and a great many of the wells thus brought back to normal production.

In seeking the cause of this reaction, operators discovered that water, because of its weight, invariably sought the lower levels and the more open channels in the sand, while the lighter oil was forced upward and sideways into the upper strata. They reasoned that if the water could be pushed back, the oil would creep in from the top and sides and thus refill the reservoir. Operators began working on this theory, with the result that water reservoirs as much as 2,000 feet underground are now being emptied with the assistance of up-to-date air equipment as efficiently as streams on the surface are being controlled.

When fresh water is first noticed in a producing oil well, the modern operator removes the tubing and rods and attaches a special head to the casing. Air furnished by a stationary, engine-driven compressor, generally of 6-cylinder construction, is next forced down into the hole. When the pressure at the casing head registers 300 to 500 pounds, usually within three or four days, the valve is opened and the pressure is allowed to "blow off" or escape. Of course, both the oil and the water in the sand are under the same pressure; but the oil, being confined in the sand nearer the well for the reasons previously explained, is the first to return to the well pocket or reservoir. Pumping equipment is then installed, and the accumulated oil withdrawn. As the oil is taken from the reservoir the water naturally flows back into it. However, as great quantities of it were forced deeper into the recesses of the sand during the period of air-pressuring, the amount reaching the well is correspondingly less. When its appearance is again noticed, air pressure is applied a second time and in the same manner. Two or three such treatments normally suffice to check the water menace in ordinary wells. In many cases, wells abandoned for years because of fresh water have been brought back into production by this process.

Oil-field compressors are in this way made to serve another purpose, thus reducing operating expenses all along the line. Aside from being used to force water from oil sands, they furnish air for driving oil from well to well, for blowing slime from shot holes, and for salvaging casings from abandoned holes. For these and various other duties of lesser importance they meet the oil man's requirements, and do so at a substantial saving in cash, labor, and time.



OIL-FIELD COMPRESSORS

For many years the trend in oil-field compressors has been towards direct-connected units, using either oil or natural gas for fuel. The machines pictured are Type XVG gas-engine-driven compressors. There are two power cylinders arranged in V-form for each horizontal compression cylinder. Compared with the older horizontal type of unit, this design has many advantages, including economy of operation.

PANAMA-CANAL ACTIVITY

THERE is an old story concerning a miner in one of the early-day western gold-mining towns who paid a visit to New York City. Upon being asked on his return what he thought of it, he replied that it looked like a permanent camp. In similar vein, we might refer to the Panama Canal as a permanent construction camp, although that would perhaps be stretching the truth a little. The fact remains, however, that after twenty-two years of service it still is a beehive of activity.

A structure such as Boulder Dam is built in six or seven years, and is then deserted by all except its operating personnel; but it will be a long time, if ever, before the Panama Canal can be said to be completed. Aside from the necessity of dredging silt from its bottom at regular intervals, there are slides to cope with rather frequently. When these tasks do not require attention, work is done on a broad program of improvement that will be underway for many years. These and other activities are handled by the Dredging Division, the scope of whose operations can best be catalogued by quoting from a book written on the subject by its superintendent, John G. Claybourn.

"Dredging and auxiliary work," wrote Mr. Claybourn, "extend throughout the entire Panama Canal and its terminal harbors, including the making of extensive hydraulic fills, such as aviation fields to prescribed grades for Army and Navy establishments, new townsites for the Panama Canal, establishment of permanent dumps for hydraulic dredge spoil, keeping in mind the improvement of sanitary conditions by filling low and swampy areas and including provisions for adequate drainage. For the disposition of dipper-dredge spoil, suitable dumps must be located, surveyed and efficiently utilized at the Pacific entrance, at the Atlantic entrance, and in the arms of Gatun Lake. Dredging output has averaged about 5,000,000 cubic yards per annum for the past ten years, of which 40 per cent was rock. Work is carried on day and night, and of the total force of approximately 1,000 persons employed one-third work on night watches. It is also necessary to require Sunday or holiday work of approximately 200 employees, principally for care-taking of floating plant. In cases of slides restricting channels, work is continuous for 24 hours per day and 7 days per week until channels are restored. At times in the past this condition has persisted for several months. In normal times tugs and suction dredges operate continuously for 24 hours, but dipper dredges and drill boats only 16 hours. Work of the division is carried on through eleven sections or subdivisions. The gross expenditures of the division amount to approximately $3,500,000 per annum, and the payroll is approximately $1,200,000."

All this work adds, of course, to the value of Uncle Sam's investment in the Isthmus of Panama, and enhances the canal's usefulness to the shipping of the world.

A DUKE'S BIRTHDAY

LAST month marked the two-hundredth anniversary of the birth of the Duke of Bridgewater, who gained his name because he was the first person in England to operate a canal that crossed a river. The duke was a coal merchant with collieries at Worsley. Because of the high charges that were made for transporting his product to Manchester and Liverpool by road and river, he commissioned James Brindley, a famous engineer, to build him a canal.

The duke's ideas were held in derision; and when Brindley proposed to carry the waterway across the Irwell River on a high bridge, people were sure that both of them were unbalanced. The feat was successfully accomplished, however, and the canal eventually carried coal, although its cost of more than $1,000,000 severely taxed the duke's resources.

Another thing for which the duke is remembered is a clock. When his employees attributed their failure to resume work promptly after the noon hour to their inability to hear the single chime of the timepiece at one o'clock, the duke devised one that struck thirteen times instead, and punctuality became the rule.

RECALLING THE PAST

A PHILADELPHIA newspaper reporter made an unusual trip last month. Driving a pair of mules that had once pulled canal boats, he traveled 250 miles in a Conestoga wagon. The journey was planned to contrast the past with the present and to commemorate a vanished conveyance that had much to do with the settling of huge sections of the United States.

The Conestoga wagon that was used is a museum piece, and was borrowed for the occasion from the Franklin Institute in Philadelphia. It was built 101 years ago. The reporter's route appropriately led westward into Lancaster County, where the Conestoga wagon had its origin. It then veered northeastward to Riegelsville, on the Delaware River, and followed that stream back to Philadelphia, paralleling the canal through which coal from the anthracite region floated to market until a few years ago. The trip required fifteen days, two of which were Sundays, when no traveling was done. An average of a little less than 20 miles was covered daily, whereas an automobile can make the entire run in a day between breakfast and dinner.

The region traversed is largely peopled by Pennsylvania Dutch, famous for their meticulously kept farms and for good cooking. Each night the reporter sent an account of the day's happenings to his paper. These dispatches stressed the things that had to do with bygone years, and included at least one recipe for some tempting dish that had been partaken. All along the way, people were surprised at the size of the Conestoga wagon, which was built for negotiating rough country and for fording good-sized streams. From the ground to its top is an even 10 feet. In two or three places, detours had to be made because it could not pass under overhead railroad crossings.

Prestressed Steel Unique Feature of Concrete Tanks

LARGE concrete tanks "that are different" have been constructed for a ranking paint concern for the storage of a fluid that weighs 105 pounds per cubic foot and has a temperature, when confined, of about 180°F. The unusual feature of these tanks is the reinforcing steel, which is prestressed and thus makes it possible for relatively thin shells to carry considerable loads and, it is claimed, to eliminate cracks resulting from tension and shrinkage.

Each tank is 12 feet high, approximately 60 feet in diameter, and has a dome-shaped roof that is conical at the center, where a revolving scraper weighing 20 tons is suspended. Because of the character of the reinforcing steel, a dome thickness of 4 inches and a wall thickness of 6 inches suffice, while the design of the roof offsets the bending stresses induced by the heavy scraper, which would otherwise have necessitated a central section 12 inches thick. The dome was poured, while the walls were placed pneumatically.

"In the particular preload method used," according to the National Gunite Contracting Company which planned and built the tanks, "the steel is in the form of smooth rods provided with upset threaded ends and sleeve nuts and coated with a special asphaltic compound to prevent any bonding with the concrete. In the dome the rods were connected during construction to form an endless steel band around the outer edge. Then after the poured concrete had set, the sleeve nuts were turned to stress the rods a definite amount corresponding to the elongation that would take place under full load. Since these radial inward stresses balanced the outward thrust due to the dead and live loads of the dome, removal of the centering placed no additional load on the rods—in effect, the tightening of the rods unloaded the centering prior to its removal. There were no subsequent deflections or distortions.

"In the tanks the tightening of the hoop rods compressed the walls, decreasing the circumference. Then when the tank was filled, the outward pressure of the liquid counteracted the compression and returned the tank to its original circumference. This left the concrete neutral except for punching shear, and increased the unit stress in the reinforcing steel to its design value.

"In stressing the vertical rods in the tank shells, they were tightened sufficiently to produce a unit compression of about 200 pounds per square inch in the concrete. This eliminated the possibility of horizontal cracks from temperature differences between the inside and outside portions of the walls.

"Prestressing of reinforcing steel suggests the possibility of using higher-strength steels, and this has been progressively demonstrated in the concrete tanks. For the first tank built a working stress of 18,000 pounds per square inch was used. Later tanks, using steel with a minimum yield point of 50,000 pounds per square inch, were designed on a 30,000-pound-unit working-stress basis. For additional tanks now under design the working stress is fixed at 40,000 pounds per square inch, using a steel with a minimum yield point of 60,000 pounds."

The original tanks have been in service for many months and are showing no signs of cracks from expansion and contraction or load carried.

Ironlike Material from Stone

RUSSIA is producing a material by the smelting of stone that is finding increasing usefulness there and that may lead to the development of an industry of considerable importance. The plant where the work is done is located in Moscow, and the raw material is a diabase. During the experimental stages of the process, and when the plant was first put in operation, ordinary paving stone was smelted.

The diabase is heated to a temperature of from 2,552 to 2,700°F. in an open-hearth furnace that burns naphtha. It travels through the furnace on a conveyor, issuing at the discharge end after a period of from four to five hours in a glowing mass that flows into a mixer where it remains for four more hours. There it undergoes partial cooling, and is then kept at a temperature of 2,160°F. After that it is drawn off into sand molds and subjected to slow cooling in a rotating oven. This is essential, for otherwise the outcome is black glass and not a substance that has the appearance of iron and rings like that metal when struck with a hammer. The process is a continuous one; and the finished material is in the form of slabs.

The product is widely used as a substitute for porcelain in the chemical and electrical industries because of its high acid- and heat-resisting properties. It is doing the work of certain metals, for it can be molded into any desired shape and is rustproof; is being made into bedplates for heavy machinery and into water pipes; combined with porcelain it is an excellent abrasive; and as a building material it is said to be effecting great economies in the erection of houses.

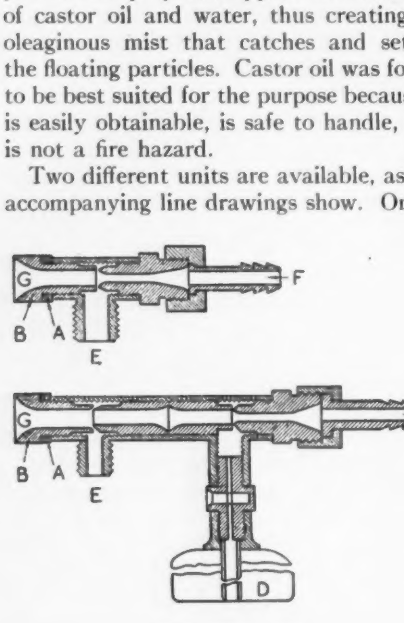
A STEAM-POWERED ELEPHANT

This freak of the foundry is a casting for the outer shell of a steam turbine as it appeared before any cleaning operations had been done on it. In its finished, machined state, it will be part of a 40,000-kw. unit. The photograph was made in the General Electric Company works at Schenectady, N. Y.

Air Spray Clears Mine Heading of Dust While Blasting

DUST raised by blasting in underground workings can be satisfactorily laid, it is claimed, by a simple device offered by a British concern. It is in the form of a compressed-air spray that applies an admixture of castor oil and water, thus creating an oleaginous mist that catches and settles the floating particles. Castor oil was found to be best suited for the purpose because it is easily obtainable, is safe to handle, and is not a fire hazard.

Two different units are available, as the accompanying line drawings show. One is a single- and the other a double-unit spray. The latter, in addition to the air and water connections, is provided with a container that holds enough oil to lay the dust at a heading 10 feet square in ten minutes. In the case of the smaller spray, the reagent is introduced by means of a line oiler interposed in the air-supply system. Both types are adjustable, and once set to produce a fog of given density require no attention. They are loosely attached to a prop behind which a curtain is suspended to confine the mist. Before the shotfirer leaves a heading to set off a blast he opens the valves admitting compressed air and water to the spray, which functions while blasting is in progress and for about ten minutes afterwards.



OIL SPRAYS

Cross section of the two types of sprays. A, lock nut; b, screw cone to adjust density of mist; d, oil container; e, water supply; f, air connection; g, adjustable cone. They are loosely held to a prop by a clip or chain, permitting them to drop when struck by fragments of rock.

Some Unusual Uses of Ice

ICE is a handy commodity, and is called upon now and then to perform some unusual service. Engineers have been known to use large cakes of it temporarily to support a heavy load, which is gradully lowered as the ice melts. Dry ice is employed to shrink metal parts so that others can be slipped over them without force, subsequent expansion assuring a tight fit. And ground is sometimes frozen by artificial means to make it stable for certain structural purposes. Still another unique method of application, that has actually been patented together with the apparatus used, has lately been reported by a gas company on the West Coast.

Public utilities are expected to maintain service under all circumstances. This sometimes offers difficulties, as in the case of high-pressure gas lines requiring tapping for purposes of extension or repair. One chief source of trouble has been overcome, we are informed, by employing ice to plug mains and thus to cut off the flow of gas in those sections on which work is in progress.

The procedure, as outlined in *Western Gas*, is as follows: At the point to be tapped is clamped a pipe saddle with a gas-main cock and a stuffing box above the cock. Through these the line is drilled and tapped to prevent the escape of gas. That done, a cold pack of cracked ice and salt is placed on each side of the saddle, or canvas containing dry ice is wrapped around the pipe. When sufficiently chilled, a mixture of water and finely shaved ice is forced into the main by a special pump, the discharge end of which is inserted into the pipe through the stuffing box and cock. This mixture soon turns into a solid piece of ice that completely fills the cross-sectional area and effectually holds the gas in check. To restore the flow the cold packs are removed; heat is applied to thaw the ice; and the drill hole is sealed with a brass plug. All this is done without interruption to service, which is maintained by means of a by-pass.

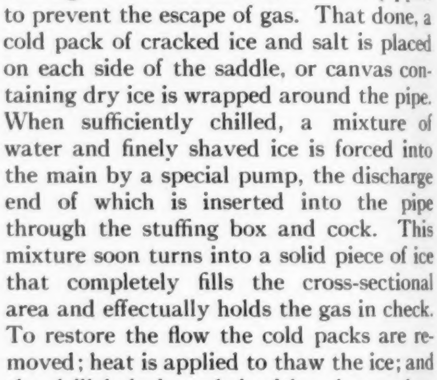
Pneumatic Equipment Expedites Cleaning Mine Lamps

CLEANING safety lamps may seem to be an unimportant item in the operation of a mine, but yet the Lehigh Navigation Coal Company has found it worth while to provide special facilities for the purpose at its Alliance Colliery at Kaska, Pa. To each man are assigned two lamps, one for use and the other for cleaning. Altogether some 278 lamps are in service, and half of them are in the lamp room each day. There they are taken apart, thoroughly cleaned, and put in their respective places on shelves along the walls. The work is done largely by compressed air, and the equipment employed was made and patented by William Jones, who is in charge of the Alliance lamp house.

The colliery has standardized on Wolf lamps, and the three different sizes in use there are taken care of by the same apparatus, which is mounted over a work bench and alongside a Wolf naphtha filling tank. The work proceeds as follows: First the wick and adjacent metal parts are brought in contact with a stationary bristle brush and then subjected to a blast of compressed air. Next all foreign matter is removed from the double-gauze air ring with compressed air, which strikes it tangentially and causes it to turn the while at high speed. The pieces of gauze are taken care of separately and while some of the other operations are in progress. They are simply put in a small chamber where they are freed of dust and dirt by blowing compressed air through them—the air being exhausted to the atmosphere by way of a pipe. Formerly, when the work was all done by hand, these gauze air rings required special handling, and were brushed only twice a week.

Cleaning of the chimney both inside and outside is virtually one operation, and is done by sliding it over a buffer mandrel provided with a curved and hinged buffer plate, both of which are covered with sheep's wool. A few revolutions of the mandrel by an air turbine, and the work is finished—the operator making sure that the inner surface is well wiped by holding the chimney for a moment to prevent it from turning with the mandrel. The air used is taken from the mine's main supply line, and is at a pressure of from 75 to 100 pounds per square inch.

With these up-to-date facilities it takes about 75 seconds under ordinary circumstances to unlock a lamp, clean it, fill it with naphtha, and reassemble it, or 20 seconds less than when the work, including the brushing of the gauze air rings, was done manually. In addition to saving time, the pneumatic equipment also assures a more satisfactory job.



Courtesy, Coal Age

A LABOR-SAVING DEVICE

Intricate as may appear the assembly of brush, buffer, and other contrivances mounted within convenient reach above the work table, it is so well arranged that every part of a mine safety lamp can be cleaned without the least lost motion. The dust and dirt removed in the process with compressed air are suitably confined and exhausted to the atmosphere.

New Uses of Nickel

NICKEL is a very conspicuous example among the few products whose use has increased despite the depression. World deliveries of that metal aggregated 80,000 tons in 1935, as compared with 68,000 tons in 1929. The major part of last year's shipments went directly into consumption. Greater diversification in its use, together with more intensified application in established fields, accounted for the growth in sales.

Most nickel serves in combination with other metals either as an alloy or a facing. Pure rolled nickel is employed chiefly for coinage and for the making of radio tubes. Five new issues of nickel coins were minted in 1935, all of them in Europe.

Steel mills absorb about half the nickel output. There are now 175 mills that produce structural nickel-alloy steels or stainless steels. The automobile industry was formerly the only important user of the structural types, but today the railway, mining, oil, and machinery-manufacturing industries consume substantial quantities of them. New, low- and intermediate-nickel-content steels of low cost are being widely utilized for the construction of railroad cars, truck bodies, oil-well casings, and other products for which there is great demand. Last year the output of stainless steel in the United States jumped by about 40 per cent.

A new technique of nickel-plating has considerably increased the use of nickel. By adding certain organic colloids to the plating solution, it is possible for the first time to achieve a brilliant nickel finish without polishing. Previously, this could be obtained only in plates too thin for commercial application. The new plating is so ductile that it will adhere to the backing metal even when the latter is bent back and forth to the breaking point. Because of its mirrorlike finish it is well suited for some services that have up to this time been performed by chromium plate. Chromium, incidentally, is customarily applied in the form of a very thin plate over a thicker plate of nickel, or sometimes over two layers of nickel having an interposed layer of copper.

Aluminum from Tailings

FROM Russia comes an announcement of interest to the aluminum industry, which has recently celebrated its fiftieth anniversary. According to *Mineral Trade Notes*, published by the U. S. Bureau of Mines, a process has been developed there for the manufacture of aluminum from nephelite waste or tailings obtained in the production of apatite by means of flotation. The process has reached a commercially practicable stage, and is to be used in a plant but lately built in Kandalakscha on the Murmansk Coast and in the neighborhood of the source of the raw material. In addition, nephelite is to supplant bauxite in the Kolchow aluminum plant, and the practicability of a similar substitution is being considered in the case of those at Tichwin and Dnjeprpstrowsk. The glass industry may also find it applicable.

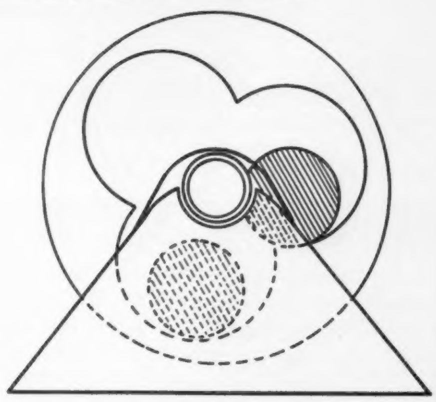
The utilization of nephelite instead of bauxite in the making of aluminum is of twofold advantage. In the first place, a waste material is converted into a useful product, and, second, soda ash actually becomes a by-product and is not consumed in large quantities as it is with bauxite. In other words, if the new process is employed on the scale contemplated, the annual yield of soda ash will amount to approximately 160,000 tons, as against the 66,000 tons that would be required if the raw material were bauxite and not nephelite. Other by-products are potash and aluminum sulphate. The Murmansk nephelite contains around 7 per cent potash, 13 per cent soda, 30 per cent alumina, and 40 per cent silica.

Combination Stamp Battery and Tube Mill

SOMETHING revolutionary in ore-crushing and milling machinery is announced from Johannesburg, South Africa, where a company is now being organized to engage in the manufacture of the equipment—a combination stamp battery and tube mill. The gravity impact roller mill, as it is called, consists essentially of a rotating drum, of a liner shaped like a 3-leafed clover, and of two heavy cylindrical weights that are carried loose in the liner. These weights drop with each revolution of the drum and serve both to break up the contained rock and to roll it into fines.

To quote the *South African Mining Review*, "The effect is described as astounding. Relatively large pieces of ore can be fed and reduced to fines in one machine. The pounding action of the stamp is embodied, also the rolling action peculiar to the drum mill. There is no rubbing nor grinding on metal. Wear, accordingly, is negligible, and the output enormous. Such large chunks can be fed that a secondary crusher can be dispensed with."

Obviously, if the claims made for it are true, the gravity impact roller mill represents a great improvement over existing facilities and promises to effect considerable savings in the cost of equipment and of preparing ore for subsequent treatment.



PRINCIPAL FEATURES

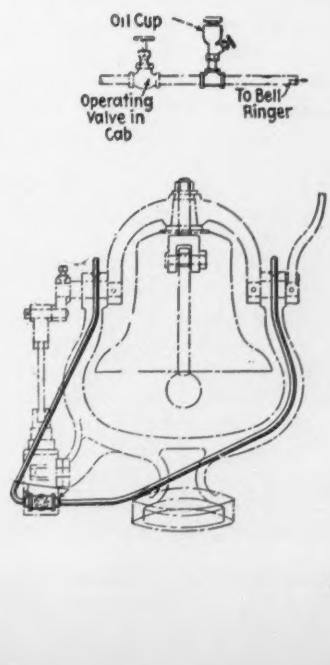
Sketch showing the arrangement of the odd-shaped liner and its two loose rollers that drop with each rotation of the outer drum and both break up and crush the ore, operations that now require the services of two units, a stamp battery and a tube mill.

Air-Line Lubricator for Locomotive Bell Ringer

MODERN locomotives, like their forerunners, carry bells that differ from the earlier ones only in the way they are operated. Now they are rung mechanically through the medium of compressed air, and some are provided with a pneumatic lubricator that is also within convenient reach of the engineer in the cab. The latter is the invention of Frank L. Staley, and has overcome, it is said, a difficulty experienced with the bell ringer.

Before starting out on a run it is the practice thoroughly to oil the trunnion bushings of the ringer; but the lubricant, by reason of the exposed position of the bell, has a tendency to flow away in the summer and to solidify in the winter, with the result that the ringer cannot always be made to function. By means of the Staley device the oil can be applied anytime from the cab while the train is underway.

The lubricator consists of a specially designed oil cup which is interposed in the line that supplies compressed air to the bell ringer. Opening the air valve simultaneously opens the feed cup—the lubricant being atomized and carried along with the air to the bell-ringer cylinder, whence it flows through two small ports into pipes leading directly to the trunnion-bushing oil holes. As the air line in the case of a modern locomotive is usually beneath its insulating jacket, the air is warm and therefore keeps the trunnions thawed out and lubricated even in the coldest weather.



Industrial Notes

Railroad rails that are believed to be free from internal fissures, the most frequent cause of breakage, are being made by a new method developed after years of research by the Bethlehem Steel Company. It is reported that the bulk of the company's 1936 rail output is to be manufactured by the new process.

According to recent press reports, experiments are to be made in the United States with refrigerated barges for the transportation of perishables. A string of four such units, each with a carrying capacity of 5 tons, is soon to be put in service between St. Louis, Mo., and Chicago, Ill., by the Inland Waterways Corporation.

The newest product of the Aluminum Ladder Company, Tarentum, Pa., is a 50-foot extension ladder that two men can handle. It is made up of three 20-foot sections which overlap one another 5 feet when extended, and of stay poles that fold against the center section when the ladder is not in use.

Microporite is a new heat-and-sound-insulating building material for interior use. It is of foreign origin and consists of a mixture of finely ground silica dust, lime, and water that is molded and treated with steam for seven hours. The product is said to weigh from 25 to 50 pounds per cubic foot and to possess great strength.

Make use of a periscope in your engine room and you will no longer have to crane your neck to read the boiler gauge. The instrument is mounted so that the image of the gauge is reflected in an adjustable mirror at the top of a telescoping floor stand ranging in height from 4 to 6 feet. Illumination of the gauge is from the side or the rear, depending up the type in service.

To prevent foot injuries in establishments where the weights to be handled do not exceed 40 pounds, Strauss Company, Inc., is offering something new in guards made of duralumin or steel weighing 7 and 14 ounces, respectively. It is designed to grip the shoe beneath the instep and is held in place by clasp springs. The guard does not touch the ground until struck by a falling weight, when a light spring under the toe end is compressed. It comes in sizes suitable for No. 5 to 12 shoes.

Protecting a base metal with a precious metal to prevent damage during certain processes of manufacture does not sound like good practice. But we have it on the authority of the chief of the division of metallurgy of the U. S. Bureau of Standards that thin coatings of silver on carbon steel during annealing will avoid oxidation and decarburization. For example, it is practicable to silverplate polished mild steel bearing finely engraved designs, to anneal it, and to strip the silver from its surfaces electrolytically, leaving the metal much as it was originally.

As a means of utilizing surplus electric energy from the Bonneville power project now under construction in Oregon, it is proposed to make use of the electric furnace for smelting iron ore, something that so far has been attempted on a commercial scale only in the Scandinavian countries. The subject is discussed in a 900-page report by the North Pacific Division of the Corps of Engineers, U. S. Army, entitled *Available Raw Materials for a Pacific Coast Iron Industry.*

What is well termed a Runaround conveyor has been announced by the Stephens-Adamson Manufacturing Company of Aurora, Ill. It is a development of the Redler conveyor, and will carry bulk material in several directions, around horizontal curves, discharge at any desired point, return any surplus to the feed point for recirculation, and is said to handle the product without breakage and the creation of harmful dust. The conveyor is an inclosed one, and is suitable for serving processing machines, etc., because it loads itself uniformly from bin or spout without the need of a feed control system.

For absorbing vibrations set up by high-speed machinery of moderate size and weight, the Elastic Asphalt Company, Chicago, Ill., has put on the market a fluid compound made of Mexican asphalt. It requires no heating, but is poured from the container in which it is sold right on to the base or foundation and troweled much like concrete. The claims made for it are that it will not extrude nor flow below temperatures of 200°F.; that it will adhere to wood, metal, and concrete; and that it is highly elastic and resilient when set. It takes from 6 to 24 hours to dry, depending upon the atmosphere.

For tools that must withstand shock and hard service, the Jessop Steel Company is manufacturing under a license a patented high-speed steel containing from 8 to 9 per cent molybdenum. The characteristics claimed for it are that it can be hammered and flows more readily under the hammer at temperatures from 100 to 200°F. lower than those at which tungsten high-speed steel can be worked; that it can be rolled as well as hardened at correspondingly low temperatures and, in the case of the latter, with less tendency to form cracks; and that it can be annealed so as to machine easily. In the annealed and hardened state Mogul, as the steel is named, is said to be tough.

Piles impregnated with metallic salts have for some time been used experimentally by the Oregon State Highway Commission in the building of highway bridges. They are apparently standing up well in service, for it is understood that the commission has recently specified that in future all piles for such work shall be "of live green timber having a sapwood ring not less than 1 inch in average thickness" and that the chemicals shall be applied under pressure "until the minimum toxic chemical content of each cubic foot of sapwood in any portion of the circumference of the treated ring and at any point in the length of the pile specified shall be 4 ounces of arsenious oxide, 6 ounces of hydrous copper sulphate, and 6 ounces of hydrous zinc sulphate."